NOAA Technical Memorandum NMFS-PIFSC-5

July 2005

The Hawaiian Monk Seal in the Northwestern Hawaiian Islands, 2002

Compiled and Edited by

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and
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EXECUTIVE SUMMARY

During 2002, field studies of the endangered Hawaiian monk seal (*Monachus schauinslandi*) were conducted at all of its main reproductive sites in the Northwestern Hawaiian Islands. These studies provide information necessary to identify and mitigate factors impeding the species recovery by evaluating (1) the status and trends of monk seal subpopulations; (2) natural history traits such as survival, reproduction, growth, behavior, and feeding habits; and (3) the success of various activities designed to facilitate population growth.

Results of these studies are best described on a site-by-site basis, and the information presented in this document is organized accordingly. Site-specific data pooled for all sites, however, provide useful indices of the status and trends of the species as a whole, including the total number of pups at all main reproductive sites, the total of the site-specific mean beach counts, and the size composition of the seals observed during the counts (Fig. 1).

Since 1983, the number of pups born at the main reproductive sites has been highly variable. In 2002, 195 pups were counted at these sites, 71 of which were born at French Frigate Shoals (FFS). Mean beach counts, excluding pups, from the main reproductive sites totaled 339 seals. Beach counts remained essentially unchanged from 1993-2000 but were lower in 2001-2002 (Fig. 1b).

From the mid-1980s to the mid-1990s, adults and pups have comprised a growing portion of the animals counted while juveniles and subadults declined (Fig. 1c), and in 2002, the composition of the counts again was dominated by adults and pups. This composition bodes poorly for reproduction in the near future if older adult females are not replaced by young females reaching reproductive age. High mortality of immature seals appears to have led to the shift in composition, particularly at FFS.

During 2002, activities conducted by the Marine Mammal Research Program (Pacific Islands Fisheries Science Center, National Marine Fisheries Service) and cooperating scientists to enhance recovery of the species included (1) disentangling of seals and removing debris capable of entangling seals; (2) monitoring beaches on Midway Atoll for disturbance and mitigating human impacts through education; (3) translocating 24 weaned pups between islets within FFS to decrease their risk of shark predation; (4) removing two Galapagos sharks after they exhibited predatory behavior toward monk seal pups at FFS; (5) treating four pups with abcesses/cellulites after sustaining punctures and scratches because of adult male aggression at FFS; (6) transfering of five weaned pups and a yearling found stranded behind a deteriorating sea wall or other barrier to a beach and released at FFS; (7) rescuing six young pups and reuniting them with their mothers (four were neonates unable to haul out of the surf due to the drag of their attached placentas, and two (a neonate and a 2-day-old pup) were caught in high surf); and (8) performing five human-assisted mother-pup exchanges, and reunited four abandoned pups with females that had lost their pups.

This document describes these and other field studies conducted during 2002 and provides complete, standardized, and timely summaries of the research activities and findings at each study site. The availability of such information is essential for ongoing efforts to stop the decline of this species and enhance its recovery.

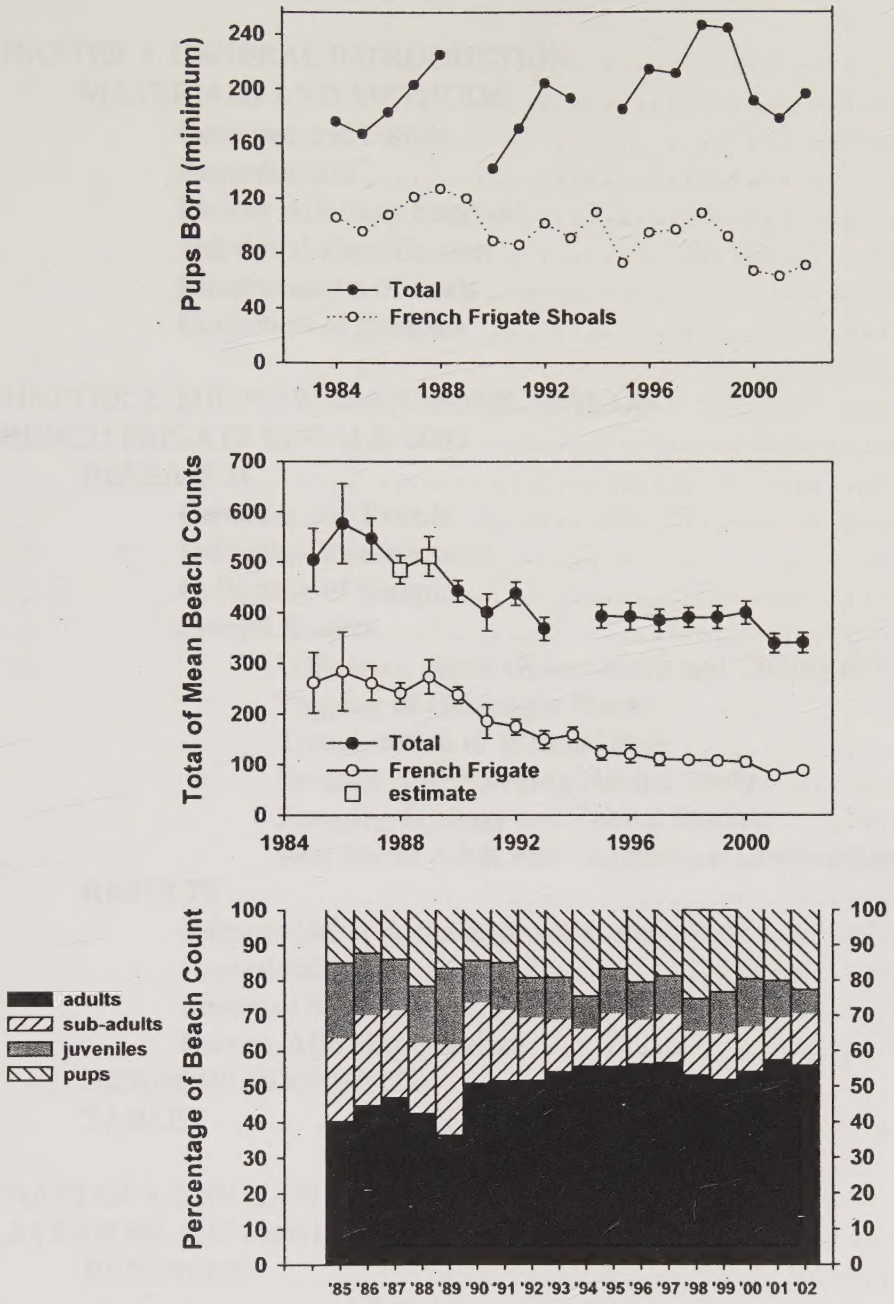
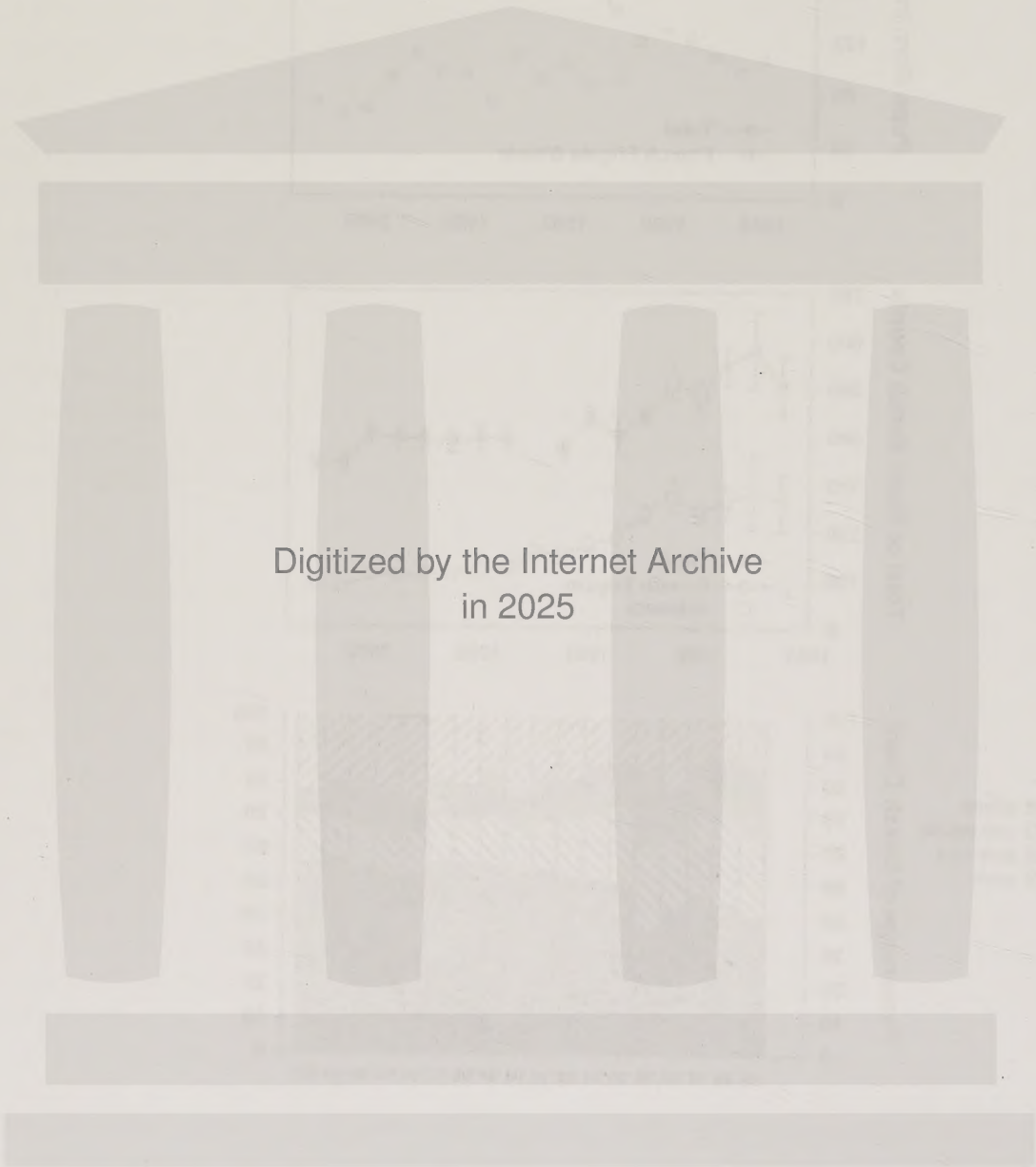


Fig. 1. Demographic trends of the Hawaiian monk seal, based on the main reproductive sites. A) Number of pups born (minimum). B) Total of mean beach counts, excluding pups, with 1 standard deviation. C) Percentage of counts composed of adults, subadults, juveniles, and pups.



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CHAPTER 1. GENERAL INTRODUCTION

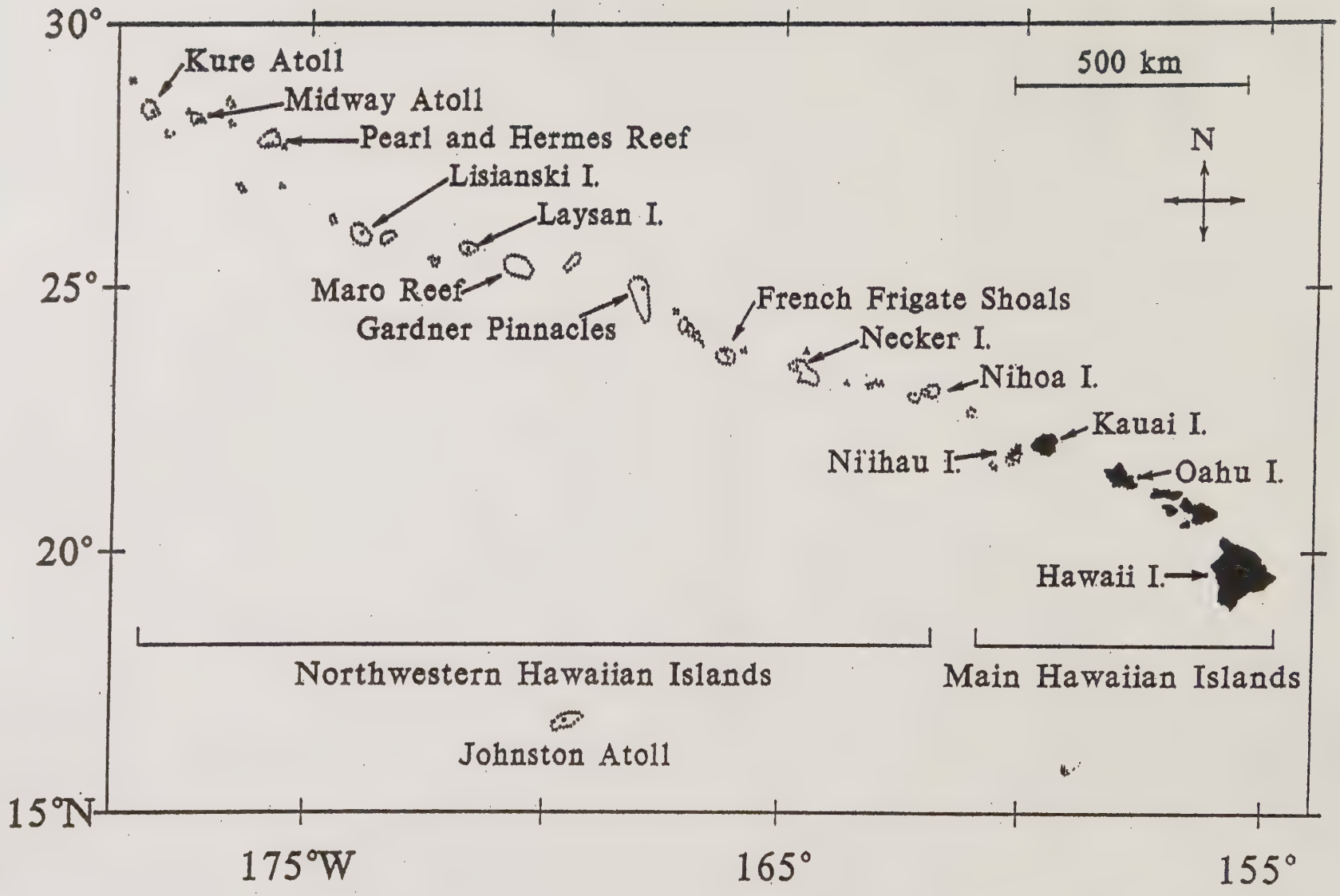

Fig. 1.1 The Hawaiian Archipelago.

The endangered Hawaiian monk seal (*Monachus schauinslandi*) hauls out and breeds in the Northwestern Hawaiian Islands (NWHI, Fig. 1.1). The National Marine Fisheries Service (NMFS) is the lead agency responsible for the recovery of the Hawaiian monk seal. Each year the NMFS Pacific Islands Fisheries Science Center, Marine Mammal Research Program conducts studies at the main breeding sites to provide information necessary to evaluate (1) the status and trends of the monk seal subpopulations; (2) natural history traits such as survival, reproduction, growth, behavior, and feeding habits; and (3) the success of various activities designed to facilitate population growth.

The Marine Mammal Research Program began research on Hawaiian monk seals at most major reproductive sites in the NWHI during 1980 (Lisianski Island), 1981 (Laysan Island and Kure Atoll), 1982 (French Frigate Shoals (FFS) and Pearl and Hermes Reef), and 1983 (Midway Atoll). Nearly every year thereafter, field camps were established for periods of several days to 9 months to monitor and enhance the recovery of this species. Limited population monitoring has also been conducted at Nihoa and Necker Islands, where subpopulations appear to be limited to a small number of animals by availability of haulout area. Reports summarizing past NMFS research are listed in Appendix A.

During 2002, Hawaiian monk seal research activities included (1) conducting beach counts (censuses); (2) tagging weaned pups and other seals for permanent identification and retagging animals to maintain identification; (3) identifying other seals by previously applied tags and by natural or applied markings; (4) monitoring reproduction, survival, injuries, entanglements, interatoll movements, disappearances, and deaths; (5) performing necropsies; (6) collecting scat and spew samples for food habits analysis; (7) collecting skin punches and shed molt samples for a DNA tissue bank; (8) collecting samples of placentas found with or from aborted fetuses or with deceased perinatal pups for histological and bacteriological examination; (9) instrumenting juvenile seals at FFS with CRITTERCAM, dive recorders, and radio transmitters as part of a juvenile foraging habitat study; (10) monitoring seals instrumented with satellite-linked dive recorders in 2001 and recovering instruments; (11) conducting shark predation studies, deterrence, and culling, and translocating weaned pups within FFS to mitigate shark predation; (12) disentangling seals; and (13) removing debris capable of entangling seals from beaches. Location-specific objectives and summaries of data collected during the 2002 field season are described in the following chapters. Much of the information presented in this memorandum is incorporated into larger data sets for additional analysis and publication elsewhere. Research was conducted under the authority of the following permits: Special Use Permits HWN-12521-0211, HWN-12521-0219, and SEPO-100102, and Marine Mammal Permit 848-1335.

MATERIALS AND METHODS

Censuses and Patrols

The primary means of data collection were censuses and patrols. Censuses consisted of timed standardized beach counts during which an entire island or atoll was surveyed for seals on foot. Although data were collected on all seals, those that were in the water, captive, or dead were excluded from the beach count totals. Identified individuals were counted only once if they were resighted during the survey. The resulting counts did not reflect total population size but provided an index of population size for comparison among years and locations. Data collected on each seal observed during censuses included size class (ranging from pup, juvenile, subadult, and adult size as described in Stone, 1984 and Appendix B), sex, location on the island, beach position (indicating whether the seal was in the water or on land), body condition (a subjective estimate; e.g., fat, medium, or thin), identification information (permanent or temporary identification numbers and tag numbers), molting status (an estimate of the percentage completed), and disturbance index (the extent that the observer disturbed the seal). Further data were collected if any of the following events occurred: (1) factors affecting survival (e.g., entanglements, mobbings, or shark injuries), (2) animal handling, (3) photography, and (4) documentation of tag condition (e.g., good or broken). In addition, behavioral data (seal associations and interactions) were collected on Laysan and Lisianski Islands. A sample census form and guidelines for its completion are included in Appendix B. Censuses were conducted once at Nihoa Island, twice at Necker Island, and every 4 to 8 days at all other locations, starting at 1300 Hawaii Standard Time when possible, using census methods and criteria outlined in Johanos et al. (1987). Atoll-wide counts for locations with more than a single island (French Frigate Shoals, Pearl and Hermes Reef, Midway Atoll, and Kure Atoll) were completed within a 2-day period. The perimeter of each study area was divided into sectors to facilitate the analysis of data and detection of demographic trends in different geographic areas. Census methods specific to each location are detailed in the following chapters.

Patrols consisted of untimed surveys of an entire island perimeter on foot. Information collected during patrols was similar to that collected during censuses. Because patrols were not timed, observers concentrated on documenting adult and subadult behavior, identifying and marking individuals, and collecting scat and spew samples. Island-specific standardized patrols were conducted at some locations and are described in the following chapters.

During all observation periods (i.e., censuses, patrols, and incidental sightings), observers attempted to minimize seal disturbance by walking above the beach crest and using vegetation as a visual barrier. On census days, activities that threatened to disturb the animals and bias the count were not conducted until after the count was completed. Additionally, the following were recorded whenever observed: (1) births, pup exchanges, and weanings; (2) mating activities, adult male aggression, and post-agression aggregations (defined below); (3) entanglements in marine debris; (4) injuries; and (5) deaths.

Reproduction

Parturient females were identified when possible, and birth and weaning information was recorded. Because parturient females will nurse pups other than their own (Boness, 1990; Boness et al., 1998), efforts were made to identify pups and document changes in nursing relationships from birth to weaning. A pup exchange occurred when the pups of two lactating females were switched or one nursing female suckled multiple pups. Typically, such exchanges occur during an aggressive interaction between the two females. On other occasions, when a mother and pup become separated, one or both seals then actively seek and obtain another nursing relationship (Boness, 1990).

The average nursing period was calculated for some or all pups at each location. The average lactation period of parturient females was also calculated for seals at FFS because higher population density and frequent pup exchanges (Boness, 1990; Boness et al., 1998) made it difficult to track individual pups and determine their nursing period. Nursing or lactation periods were defined as the number of days from birth until the end of the last nursing relationship. Temporary breaks (e.g., if a mother and pup became separated and one or both seals subsequently obtained another nursing relationship) were not subtracted from the total. When the exact birth or weaning date was not known but occurred within 4 days or less, then the midpoint of that range was used as the start or end date for calculation of average nursing or lactation period. Nursing or lactation data were not used if the birth or weaning range exceeded 4 days, or if the pup died or disappeared before weaning. Prior to 2002, nursing or lactation periods of less than 20 days were also excluded from calculations.

Factors Affecting Survival

The origins of a wide range of injuries were distinguished based upon characteristic wound patterns described in Hiruki et al. (1993). Injuries were documented if they were related to attacks by large sharks, mounting attempts by male Hawaiian monk seals, or entanglement in marine debris or if they were considered severe enough to possibly affect survival. Injuries were considered severe and were summarized if they consisted of (1) three or more abscesses, each <8 cm in diameter or one abscess with a diameter $\geq$8 cm; (2) an amputation of a minimum of half a flipper (either foreflipper or hindflipper); (3) the total combined exposed area of all punctures or gaping wounds was $\geq$8 cm diameter circle area (approximately 50cm^2); or (4) densely spaced (overlapping) scratches, abrasions, or lacerations covering an area equivalent to half the dorsum, or evidence of extensive underlying tissue damage (e.g., an uneven or darkened surface of the injured area, leaching fluids), or if they impaired seal movement. Major healed injuries that had been incurred since the previous season were documented but not included in summaries.

A seal was listed as dead if its death or carcass was observed. Deaths summarized here include carcasses found at the beginning of the field season if the seal had clearly died during the calendar year. A seal was listed as probably dead if it sustained severe injuries or was emaciated (with skeletal structure clearly evident) and subsequently disappeared. In addition, one of the following conditions must have been satisfied to place a seal in the

"probably dead" category: (1) the seal was lethargic, had difficulty moving, or floated listlessly in the water, and disappeared more than a week before the end of data collection for the field season; or (2) the seal was in deteriorating condition (loss of weight, enlargement of abscesses, sloughing of skin) and disappeared a minimum of 10 surveys or 1 month before the end of data collection for the field season (whichever was longer). Nursing pups were listed as probably dead if they disappeared within 3 weeks of birth.

Multiple male aggression (or "mobbing") and other mating-related male aggression were observed and recorded. By definition, multiple male aggression occurred when more than one male attempted to mate with a single seal, usually an adult female or immature seal of either sex, causing injury or death of that seal (e.g., Alcorn, 1984). Single male aggression was defined as any incident when one adult or subadult male repeatedly bit the dorsum, attempted to mount, and tried to prevent the escape of another seal. These incidents were summarized in this report if they simultaneously involved more than one male aggressor or resulted in a minimum of one puncture or gaping wound (missing skin or extending into the blubber layer) or $\geq$ 15 scratches to the dorsum or flanks. Post-aggression aggregations were also summarized: these were groups of males congregated on the beach, attending a seal with new mounting injuries as described above.

Individual Identification

During censuses and patrols, individual seals were identified with tags, applied bleach marks, scars, or natural markings. After weaning, pups were tagged on each hind flipper with a colored plastic Temple Tag,®[1] uniquely coded to indicate island or atoll subpopulation, year of birth, and individual identification number (Gilmartin et al., 1986). In addition, two passive integrated transponder (PIT) tags were implanted subcutaneously in the posterior dorsum of most weaned pups (see Lombard et al., 1994, for detailed tagging procedures).

Colored plastic Temple Tags have been applied to nearly all weaned pups since 1981 at Kure Atoll, since 1982 at Lisianski Island, since 1983 at Laysan Island and Pearl and Hermes Reef, since 1984 at French Frigate Shoals, and since 1995 at Midway Atoll. Pups at Midway Atoll, Necker and Nihoa Islands, and the main Hawaiian Islands have been tagged opportunistically since 1983. Since 1991, PIT tags have also been implanted subcutaneously in the ankle (1991) or the posterior dorsum (all subsequent years) of most weaned pups.

During 2002, untagged immature and adult seals were opportunistically tagged with Temple Tags uniquely coded to indicate that their ages and birth locations were unknown. These seals also received PIT tags. Seals with lost or broken tags were retagged to maintain their identities.

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[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Seals were bleach-marked for individual identification (Stone, 1984), using the solution described in Johanos et al. (1987). Molting seals were re-marked with bleach to maintain their identities until the next molt. Some nursing pups were also bleach-marked prior to the postnatal molt to facilitate identification during the nursing period.

Tags, scars, other natural markings, and any applied bleach marks were sketched by hand on a scar card for each seal, and this card was revised throughout the field season to maintain a current description of the identifying marks of each seal. Digital photographs of scars and natural markings were added to individual identification files.

Subpopulation size and composition were estimated at locations where observers rarely encountered unidentified seals during the latter part of the field season. These statistics included all individuals observed alive at the location during the interval from March through August and all known parturient females and pups born anytime during the year.

The movement of seals between island or atoll subpopulations within and between years complicates the estimation of subpopulation size and composition. This is particularly true at Midway Atoll, where a number of the observed seals were tagged at other locations (primarily Kure Atoll and Pearl and Hermes Reef). Therefore, standardized rules for assigning each seal identified to just one subpopulation are applied as follows. If a seal was observed at more than one location during March-August, it was included exclusively in the subpopulation where it was sighted nearest to May 15, unless it pupped or molted at another location. A parturient female was always exclusively included in the subpopulation where she pupped, and a nonparturient seal was exclusively included in the subpopulation where it molted. Pups were always exclusively included in the subpopulation where they were born.

Measurements of Seals

Pups were measured to provide information on body condition. Measurements were taken as soon after weaning as possible, and measurements taken within 2 weeks after weaning were included in the summaries. Measurements included straight dorsal length (Winchell, 1990) and axillary girth (American Society of Mammalogists, 1967). Older animals captured for foraging ecology, health, or disease studies were also measured.

Collection of Samples

Samples were collected for a DNA tissue bank, pathology analysis, investigation of food habits, and documentation of marine debris. Tissue punches for DNA were collected during tagging efforts for all newly tagged or retagged seals and during necropsies on seals that had died recently. Samples of placentas found with or from aborted fetuses or deceased perinatal pups were also collected.

For each dead seal recovered, an external examination was made, photographs were taken, and external measurements and observations were recorded. For a recent death, an

internal examination was made, and samples of tissue, organs, parasites, and stomach contents were collected. Detailed descriptions of necropsy procedures and sample collection methods are in Winchell (1990).

Scat and spew samples were collected opportunistically for analysis of food habits (Goodman-Lowe, 1998). These samples were collected from seals of known size and sex class, when possible.

Nets, lines, ropes, and other debris capable of entangling seals and turtles were removed from beaches. From 1982 to 1998, potentially entangling marine debris was incinerated on site at all locations, and debris incineration continued at Kure Atoll through 2001. More recently, marine debris was removed by ship.

CHAPTER 2. THE HAWAIIAN MONK SEAL ON FRENCH FRIGATE SHOALS, 2002

Suzanne M. Canja, Brenda L. Becker, Shawn C. Farry and Jennifer L. Palmer

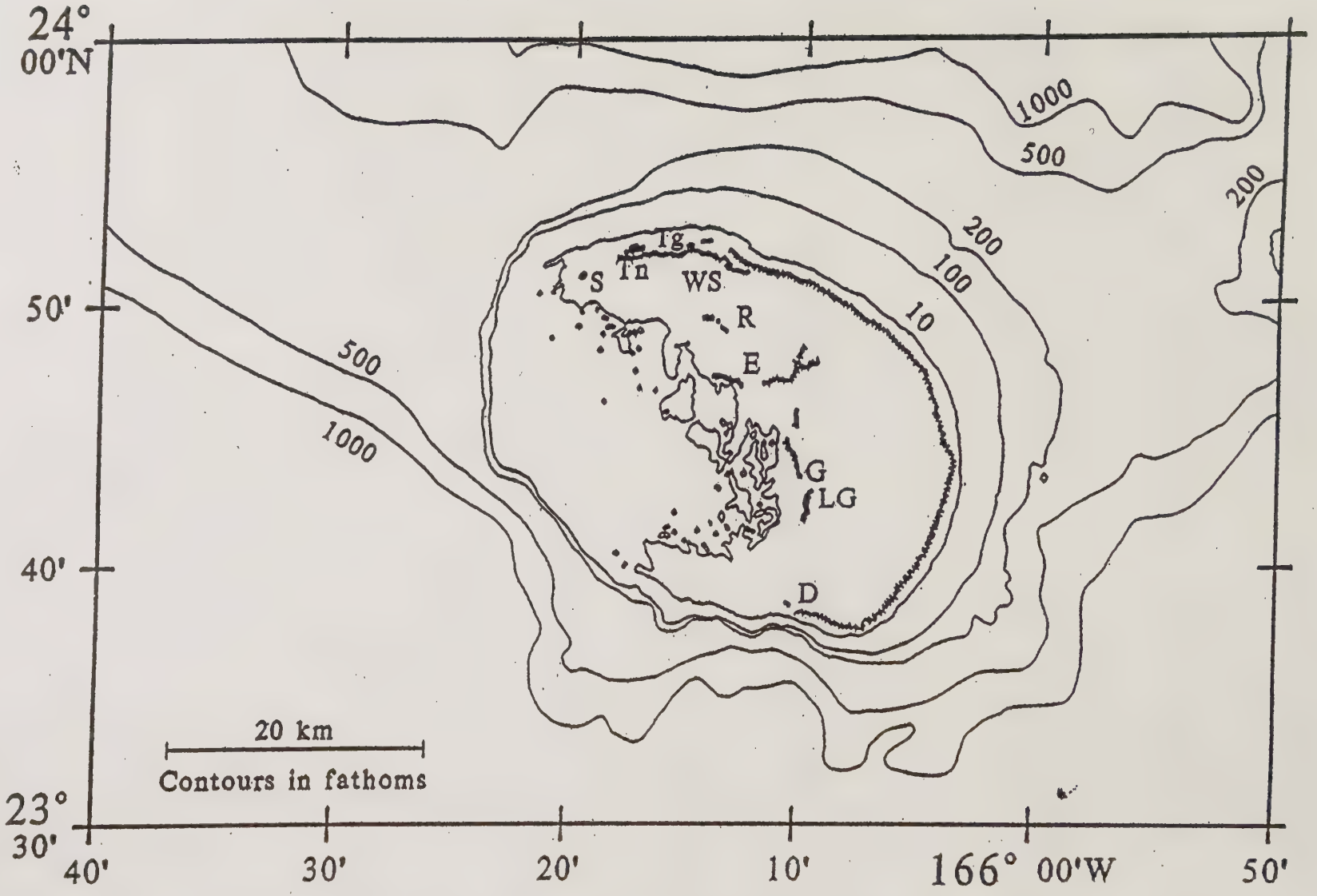

Fig. 2.1. French Frigate Shoals in the Northwestern Hawaiian Islands. Islands are: Disappearing (D), East (E), Gin (G), Little Gin (LG), Round (R), Shark (S), Tern (Tn), Trig (Tr), and Whaleskate (WS).

The largest subpopulation of Hawaiian monk seals is located at French Frigate Shoals (FFS, lat. 23°45'N, long. 166°10'W), ca. 830 km northwest of Oahu in the Northwestern Hawaiian Islands. This atoll is part of the Hawaiian Islands National Wildlife Refuge (Fig. 1.1), and consists of nine permanent islets (Disappearing, East, Gin, Little Gin, La Perouse Pinnacles, Round, Shark, Tern, and Trig), three semipermanent islets (Bare, Mullet, and Whaleskate), and several transient sand spits (Fig. 2.1).

RESEARCH

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at FFS in 1982. In 2002, research was conducted by NMFS from April 20 to September 16 and from November 30 to December 19. Incidental observations were recorded by U.S. Fish and Wildlife Service (USFWS) personnel during the rest of the year. The perimeters of the five larger islets (East, Gin, Little Gin, Tern, and Trig) were divided into sectors using artificial or natural landmarks. Research activities specific to this subpopulation in 2002 included (1) monitoring and removal of Galapagos sharks preying on monk seal pups at Trig Islet, (2) translocating newly weaned pups to reduce their risk of shark attack, (3) retagging or newly tagging seals, (4) investigating juvenile foraging ecology using seal-mounted video cameras (CRITTERCAMS) and time-depth recorders (TDRs), (5) assessing seal foraging using archival movement recorders imbedded in simulated benthic "rocks", (6) tagging Galapagos sharks to determine movement patterns within the atoll, (7) videographic surveying of benthic habitat, (8) collecting reef vertebrates and invertebrates for a Hawaiian monk seal prey fatty acid analysis, and (9) observing adult male aggression at East Island.

Censuses and Patrols

Atoll-wide censuses (n = 10) were conducted every 7 d, on average, from June 2 to August 15. Each atoll census required 2 days to complete, and data collection began between 0942 and 1733 and ended between 1010 and 1823 Hawaii Standard Time. Whaleskate, Bare, Disappearing, Round, and Mullet Islets were surveyed either by boat or on foot, while the remaining islets (East, Gin, Little Gin, Shark, Tern, and Trig) were censused on foot by 1–4 people. La Perouse Pinnacles was not routinely surveyed as there are no seal haulout sites available.

Individual islet censuses and patrols were scheduled to ensure that the entire atoll was monitored at least once each week during May 12–August 23. Surveys were more frequent at islets where most pups were born and at nearby sites. Thus, Trig was monitored every 1 - 3 days; Bare, East, Gin, Little Gin, Mullet, Round, and Tern every 3 or 4 days; and Disappearing, Shark, and Whaleskate Islets were surveyed approximately every 5 or 7 days. Whaleskate, Bare, and Mullet Islets were rarely above water during the sampling season. Round Island was awash on one survey during an extreme high tide and Disappearing was awash at the end of the season. From August 23 to September 16, a combination of patrols and full-island incidental surveys was conducted solely at Gin, East, Round, and Trig Islets

every 3 or 4 days to monitor mother/pup pairs and to document factors that may affect survival. During November 30–December 19 full-island incidental surveys were conducted at Gin, Little Gin, East, Trig, and Tern Islets to document factors affecting survival to monitor condition and survival of weaned pups, and to locate seals for tagging or retagging.

Individual Identification

A total of 327 individuals (256 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. Bleach marks were applied to 65 seals, including 24 nursing pups. Ten seals were also identified by epoxy marks applied during instrumentation. Fifty-three weaned pups were tagged with Temple Tags, 47 of which also received a passive integrated transponder (PIT) tag. Four of these pups were tagged by USFWS personnel post field season. Additionally, 57 other seals were either newly tagged or retagged with Temple Tags and most (40) received a PIT tag. These included 52 adults (34 males, 18 females), 4 juveniles (1 male, 3 females) and 1 subadult male. One adult female was tagged on two occasions, once in July and again in December because she lost her tag.

Collection of Samples

Seventy-nine scat and six spew samples were collected. Skin punches were collected from 114 seals: 106 seals during tagging and an additional 8 animals during necropsies. Tissue samples were collected from eight necropsied seals and skeletal samples from nine carcasses (one carcass was too decomposed for tissue collection). A shed molt sample was collected from one seal and nine fresh placentas were also collected. Epidemiological samples were collected from 10 instrumented seals and 75 dried ticks were also collected for epidemiological studies. In addition, a total of 369 fish and invertebrates representing 55 species were collected for fatty acid analysis. All potentially entangling marine debris were removed from beaches, brought back to Tern Island, and stored in a secure location pending removal. One net removed from an entangled seal was also collected.

Special Studies

Galapagos Shark Observations and Culling at Trig Islet

From April 20 through September 9, Trig Islet was monitored daily for 126 days (excluding 17 weather/logistical days) to document Galapagos shark activity at Trig Islet. Individual Galapagos sharks observed to exhibit predatory behavior toward monk seal pups were lethally removed. To obtain observation data during early morning and late afternoon hours, the Trig observation team spent 8 nights on the island. During the course of the season, two sharks that exhibited predatory behavior toward monk seal pups were removed; necropsies were performed and specimen samples were collected from both of these

necropsies were performed and specimen samples were collected from both of these animals.

During the culling of the second shark, an adult female seal who had lost her pup 4 days earlier (due to suspected shark predation) attacked the harpooned shark in the nearshore waters, and three other adult females joined her and repeatedly bit the shark after it was on the beach. The shark was later killed once it was a safe distance from the seals. One pup switch occurred during the confusion when the moms temporarily left their pups to attack the shark, and a human-assisted pup switch was undertaken to minimize the impacts.

Tagging of Galapagos Sharks

During June 7–15 and October 17–30, a shark research team was deployed to capture, measure, and tag Galapagos sharks in the vicinity of Trig Islet. This project is part of a study initiated in 2000 and was conducted in collaboration with California State University Long Beach, Hawaii Institute of Marine Biology, and the NMFS Narragansett Laboratory. One Galapagos shark was captured during these efforts. This shark received a highly visible identification tag in the dorsal fin and was instrumented with an acoustic tag to monitor its movements within the atoll. In addition, two gray reef sharks were caught in June and three tiger sharks were caught in October. These sharks received an external M-type capsule tag, and each tiger shark also received an acoustic tag. In addition, previously installed acoustic monitoring stations were serviced and downloaded to determine the movements of these and previously acoustic-tagged sharks.

Translocation of Weaned Pups

To reduce the risk of shark predation on monk seal pups, newly weaned pups were translocated from areas of high predation risk to islets with low evidence of shark activity. All 21 pups that weaned on Trig Islet by the end of the shark predation study on September 9 (two nursing pups remained) were translocated from Trig Islet to Little Gin (16), Gin (4), or Tern Island (one shark-bitten pup which sustained the injury at or near weaning). Two pups that weaned late in the day were temporarily moved to Tern until they could be taken to Little Gin the next day. Pups at Trig Islet were either captured and moved immediately after weaning (8), temporarily held in a pen (9), or otherwise prevented from entering the water by researchers (4) until they could be translocated. Little Gin was the primary release site because no nursing pairs were present for the weaned pups to interact with, and few seals hauled out on Little Gin, which reduced the risk of disturbing other seals during the pup releases. Because shark activity at Round Islet increased during the season, the last pup to wean there during the NMFS field season was translocated to Gin. In addition, a nursing pup that was abandoned after it sustained a lethal shark bite was taken to Tern Island to have its condition monitored and to minimize the potential for its body fluids to attract more sharks to Trig Islet. This pup died shortly after translocation.

Translocation between islets was also undertaken to increase the body condition and ultimately the survival of two pups. After its initial weaning, a small unmolted pup successfully joined a mom with a newborn pup and both pups were seen suckling from the foster mom at Round Island. However, neither pup appeared to gain much weight during the 11-13 days the two pups were with the adult female. The older pup was translocated from Round to East Islet where another mother had lost a pup 1-4 days earlier. Unfortunately, attempts to foster the translocated pup to this mother were unsuccessful.

Juvenile Seal Foraging Habitat Study

In 2001, a 2-year study was initiated in collaboration with the National Geographic Society to investigate juvenile seal foraging ecology at FFS (Littnan et al., 2004; Parrish et al., 2005). From mid-July through mid-September, nine immature seals were instrumented with a CRITTERCAM, TDR, and VHF radio transmitter. These seals included three yearlings (two males, one female), two 2-year-olds (one male, one female), and four 3-year-olds (three males, one female). CRITTERCAMS were removed from seals typically between 4–7 days after attachment, range 1–12 days. VHF radio transmitters and TDRs were left on seals an additional 11 to 49 days to investigate whether the cameras might have affected the seals' diving and foraging behaviors.

On July 23, an adult male was instrumented with an underwater still-image digital camera, Venuscam, to determine this system's functionality in monk seal foraging investigations. Both the compact camera and the VHF transmitter were removed 5 days after instrumentation.

To supplement the ongoing epidemiological investigations, blood samples were collected from 9 of the instrumented seals, and fecal, bacteriological, virological, and blubber samples were collected from all 10 seals.

During this 6-week study, the foraging investigations and all associated activities were filmed to create a "CRITTERCAM Chronicles" television episode on Hawaiian monk seals. This episode aired on the National Geographic channel in spring 2004.

Foraging Ecology and Habitat Studies

In August 2002, archival movement recorders embedded in simulated "rocks," which had been deployed in 2001 at depth in seal-foraging sites to monitor year-round foraging activity, were successfully retrieved. These instruments were downloaded, refitted, and redeployed. Videographic surveys were also conducted to map benthic habitat types. In addition, researchers also collected reef vertebrates and invertebrates for analysis of fatty acid compositions in potential monk seal prey.

East Island Adult Male Aggression Observations

In June, observations for adult male aggression on East Islet were increased substantially after a newly weaned pup was observed on June 6 being mounted and bitten by an adult male. The initial injury appeared minor but subsequently developed into cellulitis. Consequently, two doses of antibiotics were administered to prevent infection. After 3 weeks of intensive observations, no other aggressive interactions were documented, and the East Islet observations were scaled back to standard patrols completed every 3–4 days.

In late August and early September, three weaned pups at East Islet sustained recent seal-inflicted punctures or scratches. Although the circumstances surrounding these injuries were not witnessed, they were consistent with single adult male aggression. Two of these injuries lead to abscesses and the third to a seroma/hematoma. All three pups were treated by or under the direction of a veterinarian. One pup's abscess ruptured on its own and was thoroughly cleaned. Raised areas on the other two pups were lanced and subsequently cleaned. Each of the pups was given between 1 and 4 doses of antibiotics. In addition, East Islet observations were again increased to look for further incidents of male aggression. Two observers were dedicated specifically to carrying out this task from August 29 until the end of the field season for a total of 18 days. However, no unusual behavior or aggressive interactions were witnessed during that time.

RESULTS

Subpopulation Abundance and Composition

The mean (±SD) of 10 atoll censuses was 119.9 seals (± 10.4) including pups, and 85.1 seals (± 10.5) excluding pups (Table 2.1). Total seals identified as part of the spring-summer subpopulation were 313 individuals, 242 excluding pups (Table 2.2). This number is a subset of the total identified in the calendar year and is an unknown proportion of the total subpopulation, as many of the older, untagged seals could not be uniquely identified. The numbers of tagged known-age seals born at FFS during the period from 1984 to 2001, and resighted at any location in 2002, are summarized in Table 2.3.

Reproduction

At least 71 pups were born at FFS in 2002: 53 were successfully weaned (including one born after and three nursing at the end of the NMFS field season), 17 died or disappeared prior to weaning (including a neonate that USFWS documented before the NMFS field effort), and the fate is unknown of one pup nursing at the end of the NMFS field season (Table 2.4a). Two sets of twin pups (one set both male and the other both female) were born at FFS, the first ever documented twin births in the Northwestern Hawaiian Islands. The male twins died within 4 days of birth. After sustaining a severe shark bite, one of the female twins died just 1-5 days before her twin successfully weaned. Nursing periods

and measurements of weaned pups are summarized in Table 2.4b. The mean (±SD) lactation period for 47 females was 37.0 d (±4.2 d). One pup had an unusually long nursing period, 77–88 days; it initially weaned at 32–42 days, and 20–22 days later this pup was naturally fostered for 23–26 more days by an adult female whose birth pup had disappeared 3–6 days earlier. Thirty-nine pup exchanges were documented between 22 adult females; 7 of these events were observed and 6 others occurred when researchers intervened to improve the survival of a nursing pup. Six nursing pups were reunited to their mothers, including one set of twins that frequently got separated from their mother. In addition, several unsuccessful attempts were made to reunite a seriously shark-bitten pup with its mother. Five births were also observed. After the loss of a pup, two nursing adult females attended a single pup for at least 2 days.

Interatoll Movement

Interatoll movement was documented for four seals that completed a total of five movements between FFS and either Necker or Laysan Islands (Tables 2.5a and b). Because of limited field effort at Necker, seals that move to this location from FFS have a low sighting probability. In 2002, an animal last seen at Necker Island in 1999 was observed at FFS, and another last seen at FFS in 1994 was observed at Necker Island. Both seals were adult males born at FFS in 1987.

Factors Affecting Survival

Attacks by large sharks, mounting attempts by male Hawaiian monk seals, entanglement in marine debris, emaciation, and other/unknown factors led to 38 life-threatening conditions, which resulted in the confirmed deaths of 8 seals and the probable deaths of 14 seals: 11 nursing pups, 1 adult, and 2 yearlings (Table 2.6). Four nursing pup disappearances occurred at Round, two each at Trig and East, and one each on Gin, Tern, and Disappearing Islets.

Six pups received moderate to severe shark bites: three at Trig (including one lethal injury), two at Round (one pup died and the other disappeared after receiving a severe shark bite), and one lethal bite at East. An additional pup received a very minor shark injury at Trig, not serious enough to include in Table 2.6. Shark attack was the suspected cause for the disappearances of seven other pups (two each at Trig, Round, and East, and one at Gin), as these pups appeared healthy and normal prior to their disappearances. In addition, there were numerous observations of Galapagos sharks patrolling and attempting to attack pups on Trig Islet and large shark sightings in the nearshore waters of Round and East Islets. Shark predation (known or inferred) resulted in the loss of 15.7% (11 of 70) of the live-born pups at FFS. Losses to shark predation (known or inferred) were the highest at Round Islet, affecting 50% (4 of 8) of the pups born.

Only one incident of adult male aggression was observed, resulting in a moderately severe cellulitis in a weaned pup. Two seals were entangled: a nursing adult female freed herself and researchers disentangled the other seal.

In addition to the incidents presented in Table 2.6, five weaned pups were stranded behind the deteriorating seawall and one juvenile was stranded behind a barrier fence at Tern Island. All six seals were removed by researchers (four by NMFS staff and two by USFWS staff); however, one sustained a minor injury from the entrapment. Four of these entrapments were found on the north side of the island between sectors 8 and 9 and were discovered by USFWS personnel during morning "entrapment" walks around Tern. A mummified carcass of a 2-year-old seal was found at the beginning of the season. This seal had died of unknown causes since the previous field season. An adult female was observed emaciated and in declining condition throughout the season. Another adult female had a large healed male-mounting scar that had been inflicted since the previous field season. An undersized pup weaned prior to the field season subsequently sustained seal-inflicted scratches. This seal was last seen in poor condition on June 10 and probably disappeared. Lastly, at or in the wavewash, researchers cut the umbilical cords of four newborn pups whose movements were restricted by their attached placentas.

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TABLES

Table 2.1.--Summary statistics for atoll censuses (n = 10) of Hawaiian monk seals at French Frigate Shoals from June 2 to August 15, 2002.

Size/Sex	Mean number of individuals	Standard deviation
Adults	68.4	8.4
Male	20.4	5.3
Female	45.0	4.4
Unknown	3.0	2.1
Subadults	8.3	2.0
Male	5.1	1.4
Female	3.0	1.1
Unknown	0.2	0.4
Juveniles	8.4	3.4
Male	3.0	2.0
Female	5.3	2.4
Unknown	0.1	0.3
Pups	34.8	3.6
Male	12.1	3.4
Female	17.2	3.7
Unknown	5.5	3.7
Non-pup Total	85.1	10.5
Grand Total	119.9	10.4

Table 2.2.--Composition of the Hawaiian monk seal subpopulation at French Frigate Shoals during the spring and summer of 2002. These numbers are an unknown proportion of the entire subpopulation, as many untagged adults could not be uniquely identified. All known parturient females and pups born during the calendar year are included.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	72[a]	116[a]	0	188[a]	0.6:1
Subadults	12	9	0	21	1.3:1
Juveniles	16	17	0	33	0.9:1
Pups	29	37	5	71	0.8:1
Non-pup Total	100[b]	142[b]	0	242[b]	0.7:1
Grand Total	129[b]	179[b]	5	313[b]	0.7:1

[a] These numbers are an unknown proportion of the entire adult subpopulation.
[b] These numbers are a minimum population estimate.

Table 2.3.--Summary of tagged known-age seals born at French Frigate Shoals and resighted at any location in 2002.

Cohort Year	Age (years)	Sex	Number originally tagged	Number resighted in 2002
1984	18	Male	49	6[a]
		Female	43	11[a]
1985	17	Male	48	3[a]
		Female	38	10[a]
1986	16	Male	52	5[a]
		Female	48	17[a]
1987	15	Male	55	9
		Female	51	6
1988	14	Male	52	4
		Female	62	5
1989	13	Male	51	6
		Female	50	5[a]
1990	12	Male	38	1
		Female	41	6[a]
1991	11	Male	24	1
		Female	44	4[a]
1992	10	Male	36	2
		Female	55	9[a]
1993	9	Male	40	2
		Female	39	2
1994	8	Male	47	1
		Female	48	7[a]
1995	7	Male	29	2
		Female	26	11[a]
1996	6	Male	39	3
		Female	30	3
1997	5	Male	32	1
		Female	19	0
1998	4	Male	49	4
		Female	39	6

Cohort Year	Age (years)	Sex	Number originally tagged	Number resighted in 2002
1999	3	Male	30	7
		Female	30	4
2000	2	Male	27	4
		Female	30	5
2001	1	Male	21	9
		Female	19	11

[a] Cohort survivors include seals removed from French Frigate Shoals for rehabilitation or direct translocation. These seals were either released at Kure or Midway Atoll ($n = 16$) or remain in permanent captivity ($n = 13$).

Table 2.4a.--Summary of Hawaiian monk seals born at French Frigate Shoals in 2002.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	29[a,b]	36[a]	6[c]	71[a]
Died/probably died prior to weaning	4[d]	7[e]	6	17
Fate Unknown	0	1[f]	0	1
Weaned	25[g]	28	0	53
Tagged	25	28	0	53

[a] Total includes two sets of twin pups (one pair of male twins and one pair of female twins).
[b] One male pup was born after the NMFS field camp on Tern.
[c] One pup was born on Tern Island and disappeared on its day of birth before the NMFS camp.
[d] Both male twin pups died within 4 days of birth.
[e] One of the female twins died after sustaining a lethal shark bite.
[f] One female pup was nursing on Trig at the end of the NMFS field camp and was not seen again.
[g] USFWS tagged, after weaning, the three male pups that were still nursing at the end of the NMFS field camp and the pup born after the NMFS camp.

Table 2.4b.--Summary of nursing periods and measurements of weaned pups at French Frigate Shoals in 2002. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)	Mass (kg)
Mean	38.4	104.5	125.1	68.6
St. Dev.	5.2	8.4	6.9	--
n	28	47	47	1

Table 2.5a.–Documented movement of Hawaiian monk seals to French Frigate Shoals from other locations in 2002, summarized by movements between two locations. No seals made more than one observed trip.

Original location	Number of trips, size, and sex class
Necker Island	1 adult male
Laysan Island	2 adult female

Table 2.5b.–Documented movement of Hawaiian monk seals from French Frigate Shoals to other locations in 2002, summarized by movements between two locations. No seals made more than one observed trip.

Destination	Number of trips, size, and sex class
Necker Island	1 adult male
Laysan Island	1 adult female

Table 2.6.--Factors affecting Hawaiian monk seal survival at French Frigate Shoals in 2002.

			Outcome		
Size	Sex	Total	Injured	Died	Probably died
Attack by Large Shark					
Adult	Male	3	3[a]	0	0
	Female	1	1	0	0
Subadult	Female	1	1	0	0
Weaned pup	Male	2	2[b]	0	0
Nursing pup	Male	1	0	1[c]	0
	Female	3	0	2[d]	1[e]
Mounting by Males					
Subadult	Male	1	1	0	0
Weaned pup	Female	1	1[f]	0	0
Entanglement					
Adult	Female	1[g]	0	0	0
Juvenile	Male	1	1[h]	0	0
Emaciation					
Adult	Male	1	0	0	1[i]
Juvenile	Female	4	0	2[j]	2[k]
Other/Unknown					
Subadult	Male	2	2[l]	0	0
Weaned Pup	Male	2	2[m]	0	0
	Female	1	1[n]	0	0
Nursing pup	Male	3	0	2[o]	1
	Female	4	0	1[p]	3[q]
	Unknown	6	0	0	6[r]

[a] One injury occurred post field season, observation reported by USFWS personnel.

[b] One injured pup was translocated to Tern island within 19 hrs of weaning; the other injured pup was reported by USFWS personnel post NMFS field season.

[c] A nursing pup was seen alone the day following a severe shark bite. After three unsuccessful attempts by researchers to reunite the pup with its mom, the pup was

translocated to Tern where he died a few hours later.

[d] One pup (twin) likely incurred injury after separation from mom and sibling. Both twins were frequently separated from their mother during the nursing period. This pup died 1-5 days before her twin successfully weaned.

[e] A pup sustained two severe shark injuries prior to weaning. The pup was seen weaned, yet disappeared later that day and was not seen again.

[f] Mounting was witnessed by observers. The resulting injury appeared minor and developed into cellulitis. Antibiotics were administered.

[g] A parturient female freed herself from loose-fitting debris on beach after being intentionally distracted by field staff.

[h] USFWS personnel released seal from debris post NMFS field season. Seal incurred deep injury around neck from tight-fitting net.

[i] Adult male was emaciated and then sustained a moderately severe shark bite. His condition continued to decline and he was last seen on July 6.

[j] One emaciated seal sustained a minor shark bite to its hindflippers just two weeks before its death.

[k] Two emaciated yearling females were in declining condition; one was last seen May 20 and the other on June 6.

[l] One seal instrumented with CRITTERCAM incurred a substantial gash on top of his head, unknown if related. All instrumentation was immediately removed without additional injury to seal. Wound had nearly healed by end of field season. The other subadult was seen in December during the tagging trip with a lump (non-abscess) on the posterior dorsum where the VHF/TDR instrument pack had been epoxied to the seal. In the center of the raised area were two seal-inflicted scratches. It is unclear what caused the lump.

[m] Both pups developed abscesses that were lanced and treated with antibiotics by a veterinarian. The injuries were seal inflicted.

[n] Seal developed a seroma/hematoma from a seal-inflicted injury. The injured area was lanced and antibiotics administered.

[o] Full-term twin pups died within 4 days of birth.

[p] Birth was observed and shortly afterwards the pup tumbled down the beach into the shoreline wavewash. Researchers rescued the pup from the surf within 20 min of birth. The pup was found dead the next day.

[q] An adult female suckled her newborn pup and a prematurely weaned pup for 11–13 days on Round Island. Neither pup showed obvious signs of weight gain, and the older pup was translocated in attempts to foster him to another adult female. The younger pup disappeared 4–6 days later. Extreme high tides occurred during this period and may have been a factor in the pup's disappearance.

[r] Prior to the NMFS field season, one newborn pup was seen on its day of birth (unknown if it was alive) by USFWS personnel and then disappeared later that day (suspected washed out to sea).

CHAPTER 3. THE HAWAIIAN MONK SEAL ON LAYSAN ISLAND, 2002

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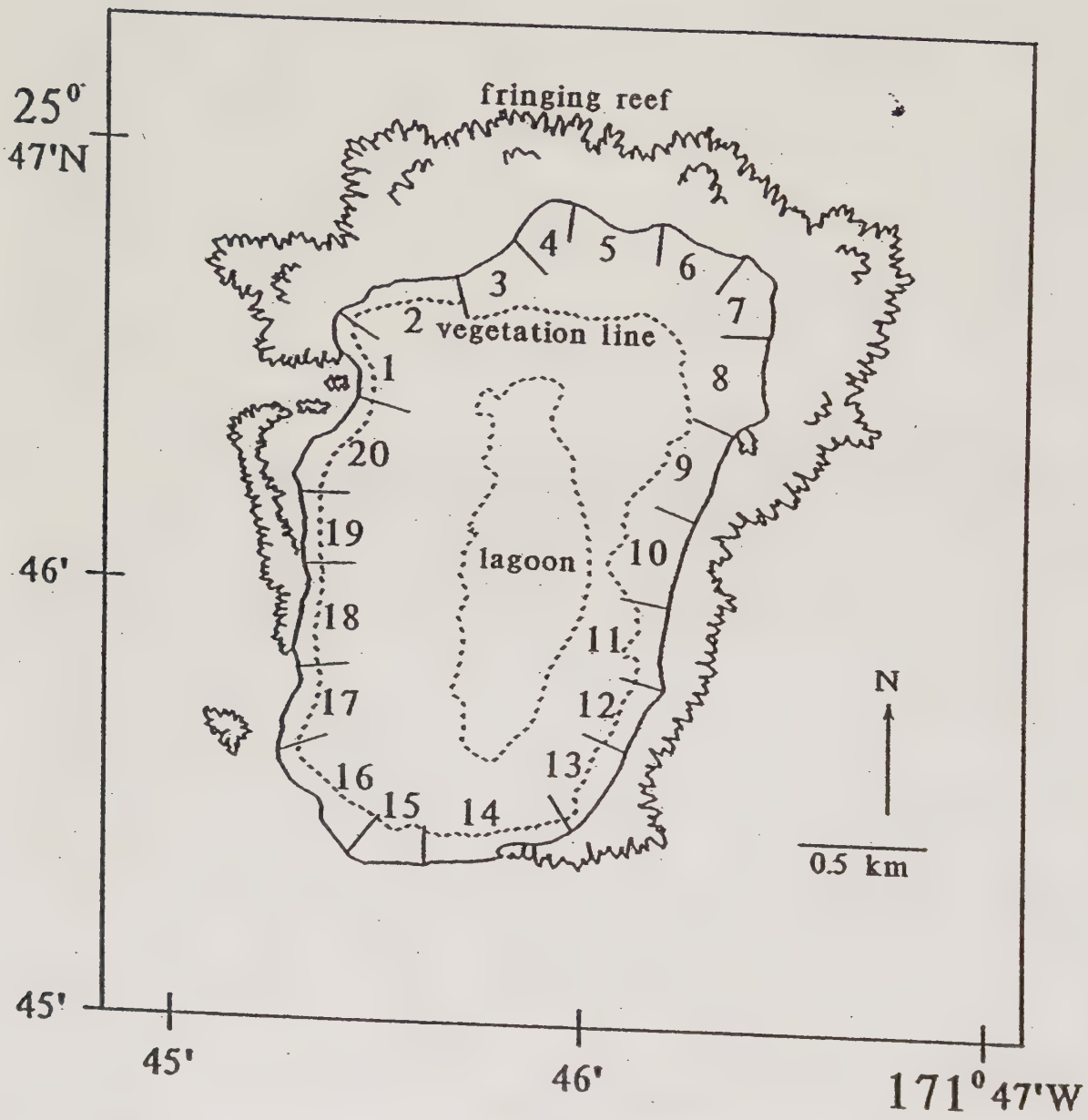

Fig. 3.1 Laysan Island in the Northwestern Hawaiian Islands.

Laysan Island (lat. 25°42'N, long. 171°44'W) is located ca. 1,300 km northwest of Oahu in the Northwestern Hawaiian Islands (Fig. 1.1). This island lies within the Hawaiian Islands National Wildlife Refuge and is one of the six primary haulout and pupping locations of the Hawaiian monk seal (Fig. 3.1).

RESEARCH

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at Laysan Island in 1981. In 2002, research was conducted by NMFS during March 19-July 18, and incidental observations were recorded by U.S. Fish and Wildlife Service (USFWS) personnel during the remainder of the year. The perimeter of the island (ca. 11 km) was divided into 20 sectors using artificial or natural landmarks (Fig. 3.1). Research objectives specific to this subpopulation in 2002 included (1) assessment of maternity and pup exchanges; (2) documentation of male behavior, including aggression; and (3) monitoring seals equipped with satellite-linked dive recorders in 2001 and recovering these instruments.

Censuses and Patrols

Censuses and patrols were scheduled to ensure that the entire island perimeter was monitored at least once daily during March 24–July 14. Censuses (n = 22) were conducted by two observers every fourth day from April 21 to July 14, beginning at 1300 Hawaii Standard Time and continuing for 2.9 to 6.0 h.

Standardized behavior patrols were conducted on 21 noncensus days from April 24 to July 12 to assess behavior of adults and large subadults, including aggression. During behavior patrols, observer attention was directed out to sea as much as possible, as multiple male aggression has been observed most frequently in the water. Fifty-eight full-island incidental patrols to record noteworthy events were conducted on noncensus and nonbehavior patrol days.

Individual Identification

A total of 282 individuals (245 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. Bleach marks were applied to 248 seals, including 30 nursing pups. All pups that weaned prior to the end of the NMFS field camp (n = 31) were tagged with Temple Tags and also received passive integrated transponder (PIT) tags. Six additional pups weaned after the camp and were bleach-marked by USFWS personnel.

Collection of Samples

Ninety-eight scat and nine spew samples were collected. Skin punches were collected from 31 weaned pups during tagging. A single necropsy was performed on a stillborn pup and tissue samples were collected from the carcass. All potentially entangling marine debris was collected from beaches and stored at secure sites around the island pending removal.

Special Studies

Foraging Ecology

During October 2001, 30 seals on Laysan Island were captured and outfitted with satellite-linked dive recorders (SLDRs). Twenty-seven of these seals were resighted during the 2002 field season. Five seals lost their instruments during the season, three of which were recovered. Two successful attempts were made to remove weakly attached units from sleeping seals (one adult female, one subadult female). One unsuccessful attempt was made to remove a SLDR from an adult male. However, this individual later shed his instrument, which was subsequently recovered. The 20 remaining attached tags were all observed lifting from the dorsal surface to various degrees by the end of the field season.

RESULTS

Subpopulation Abundance and Composition

The mean (±SD) of 22 censuses was 99.4 seals (±11.9) including pups, and 77.6 seals (±12.1) excluding pups (Table 3.1). The total spring-summer subpopulation was 274 individuals, 237 excluding pups (Table 3.2). This number is a subset of the total identified in the calendar year. The overall adult sex ratio was at 0.8:1 (63 males: 83 females). The numbers of tagged known-age seals born at Laysan Island during the period from 1983 to 2001, and resighted at any location in 2002, are summarized in Table 3.3.

Reproduction

At least 37 pups were born at Laysan Island in 2002, and all were successfully weaned (Table 3.4a). Nursing periods and measurements of weaned pups are summarized in Table 3.4b. The birth rate measured as the number of pups born divided by the number of adult-sized females in the subpopulation X 100 was 44.6% ((37/83) X 100). A minimum of 13 pup exchanges occurred between 13 nursing females. This includes the following human-assisted pup exchange. As a result of previous pup exchanges, an adult female simultaneously nursed two pups for a 3-day period. This situation was remedied by physically returning one of the pups to its birth mother in order to improve survival chances for both pups. Pup numbers exclude an aborted fetus found in April. The adult female who

aborted the fetus was without a pup for 36 days, briefly nursed a "weaned" pup, and then began nursing an 8-day-old pup 39 days after losing her own pre-term pup. She nursed this foster pup for 33 days and weaned it successfully.

Interatoll Movement

Interatoll movement was documented for 17 seals that completed a total of 30 movements between Laysan Island and either French Frigate Shoals, Lisianski Island, or Kure Atoll (Tables 3.5a and b).

Factors Affecting Survival

Attacks by large sharks, mounting attempts by male Hawaiian monk seals, entanglement in marine debris, and emaciation led to 11 life-threatening conditions, which resulted in the confirmed death of one seal and the probable deaths of two seals (Table 3.6). Although incidents of prolonged adult male aggression were not observed, one adult male sustained extensive dorsal wounds from such an encounter. A yearling male disappeared by early June and is presumed dead following observation of large shark bites to the shoulder and head (eye) areas. Another yearling male was noted as small and thin, but not emaciated, throughout the season and was found dead by USFWS in August 2002. A severely emaciated male was last observed in late April and is presumed dead. One weaned female pup was entangled and released by observers with no apparent adverse effects. In addition to the incidents presented in Table 3.5, an aborted fetus was recovered from a female who also lost a pup to perinatal death in 2001, and a subadult female was observed with extensive, but well healed, scars attributed to male mounting that were not observed the previous year.

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TABLES
for Laysan Island

Table 3.1.--Summary statistics for censuses (n = 22) of Hawaiian monk seals at Laysan Island from April 21 to July 14, 2002.

Size/Sex	Mean number of individuals	Standard deviation
Adults	48.2	7.5
Male	18.7	4.6
Female	29.2	5.1
Unknown	0.3	0.6
Subadults	20.8	5.7
Male	10.0	3.3
Female	10.7	3.8
Unknown	0.1	0.3
Juveniles	8.6	2.7
Male	4.0	1.9
Female	4.5	1.4
Unknown	0.1	0.3
Pups	21.8	5.1
Male	13.7	4.1
Female	8.0	1.7
Unknown	0.1	0.3
Non-pup total	77.6	12.1
Grand total	99.4	11.9

Table 3.2.--Composition of the Hawaiian monk seal subpopulation at Laysan Island during the spring and summer of 2002. Includes all known parturient females and pups born during the calendar year.

	Number of seals			
Size	Male	Female	Total	Sex ratio male:female
Adults	63	83	146	0.8:1
Subadults	29	36	65	0.8:1
Juveniles	13	13	26	1.0:1
Pups	21	16	37	1.3:1
Non-pup total	105	132	237	0.8:1
Grand total	126	148	274	0.9:1

Table 3.3.--Summary of tagged known-age seals born at Laysan Island and resighted at any location in 2002.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2002
1983	19	Male	10	1
		Female	10	6
1984	18	Male	16	4[a]
		Female	13	4
1985	17	Male	16	2
		Female	14	4
1986	16	Male	15	0
		Female	17	2
1987	15	Male	13	3
		Female	15	5
1988	14	Male	23	4
		Female	17	2
1989	13	Male	16	2
		Female	13	2
1990	12	Male	7	2
		Female	9	2
1991	11	Male	18	7
		Female	13	3
1992	10	Male	18	2
		Female	14	3
1993	9	Male	23	4
		Female	14	5
1994	8	Male	18	7
		Female	29	7
1995	7	Male	16	7
		Female	21	9
1996	6	Male	23	7
		Female	21	10
1997	5	Male	19	5
		Female	16	7

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2002
1998	4	Male	24	13
		Female	20	10
		Unknown	1	0
1999	3	Male	20	9
		Female	34	19
2000	2	Male	14	2
		Female	20	3
2001	1	Male	16	11
		Female	17	10

[a]Cohort survivors include a seal removed from Laysan Island and translocated to the main Hawaiian Islands.

Table 3.4a.--Summary of Hawaiian monk seals born at Laysan Island in 2002.

Event	Number of pups		
	Male	Female	Total
Born	21	16	37[a]
Died prior to weaning	0	0	0
Weaned	21[b]	16[c]	37
Tagged	21[b]	16[c]	37

[a]Number excludes an aborted fetus.
[b]Includes one pup weaned and bleached by USFWS after the NMFS Camp and tagged in 2003.
[c]Includes five pups weaned and bleached by USFWS after the NMFS camp; one of these was also born after the NMFS camp. All five pups were tagged in 2003.

Table 3.4b.--Summary of nursing periods and measurements of weaned pups at Laysan Island in 2002. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	38.8[a]	110.0	122.4
Standard deviation	5.7	6.4	5.6
n	34	30	30

[a]Includes one pup who was initially weaned at 39 days and went on to nurse from two other females, resulting in total nursing period of 62 days.

Table 3.5a.–Documented movement of Hawaiian monk seals to Laysan Island from other locations in 2002, summarized by movements between two locations. One seal made more than one observed trip.

Original location	Number of trips, size, and sex class
French Frigate Shoals	1 adult female
Lisianski Island	2 adult male 9 adult female 1 subadult male 2 subadult female

Table 3.5b.–Documented movement of Hawaiian monk seals from Laysan Island to other locations in 2002, summarized by movements between two locations. No seals made more than one observed trip.

Destination	Number of trips, size, and sex class
French Frigate Shoals	2 adult female
Lisianski Island	1 adult male 7 adult female 2 subadult male 2 subadult female
Kure Atoll	1 adult female

Table 3.6.--Factors affecting Hawaiian monk seal survival at Laysan Island in 2002.

			Outcome		
Size	Sex	Total	Injured	Died	Probably died
		Attack by Large Shark			
Adult	Male	1	1	0	0
Subadult	Female	3	3	0	0
Juvenile	Male	1	0	0	1[a]
Weaned pup	Male	1	1	0	0
		Mounting by Males			
Adult	Male	1	1	0	0
Juvenile	Female	1	1	0	0
		Entanglement			
Weaned pup	Female	1[b]	0	0	0
		Emaciation			
Adult	Male	1	0	0	1[c]
Juvenile	Male	1	0	1[d]	0

[a]Seal had large bite on right shoulder and through left eye. Appeared sluggish and unresponsive at time of final observation; not seen for last 40 days of camp.
[b]Seal freed by observer from line around neck; sustained no injuries from the entanglement.
[c]Seal not observed final 3 months of camp.
[d]Seal noted as small for age and thin, but never emaciated, throughout field season. Found dead after NMFS Camp by USFWS personnel. It was described as emaciated at the time of death.

CHAPTER 4. THE HAWAIIAN MONK SEAL ON LISIANSKI ISLAND, 2002

Elizabeth Jenkinson, Bruce Casler and Maia Yannacone

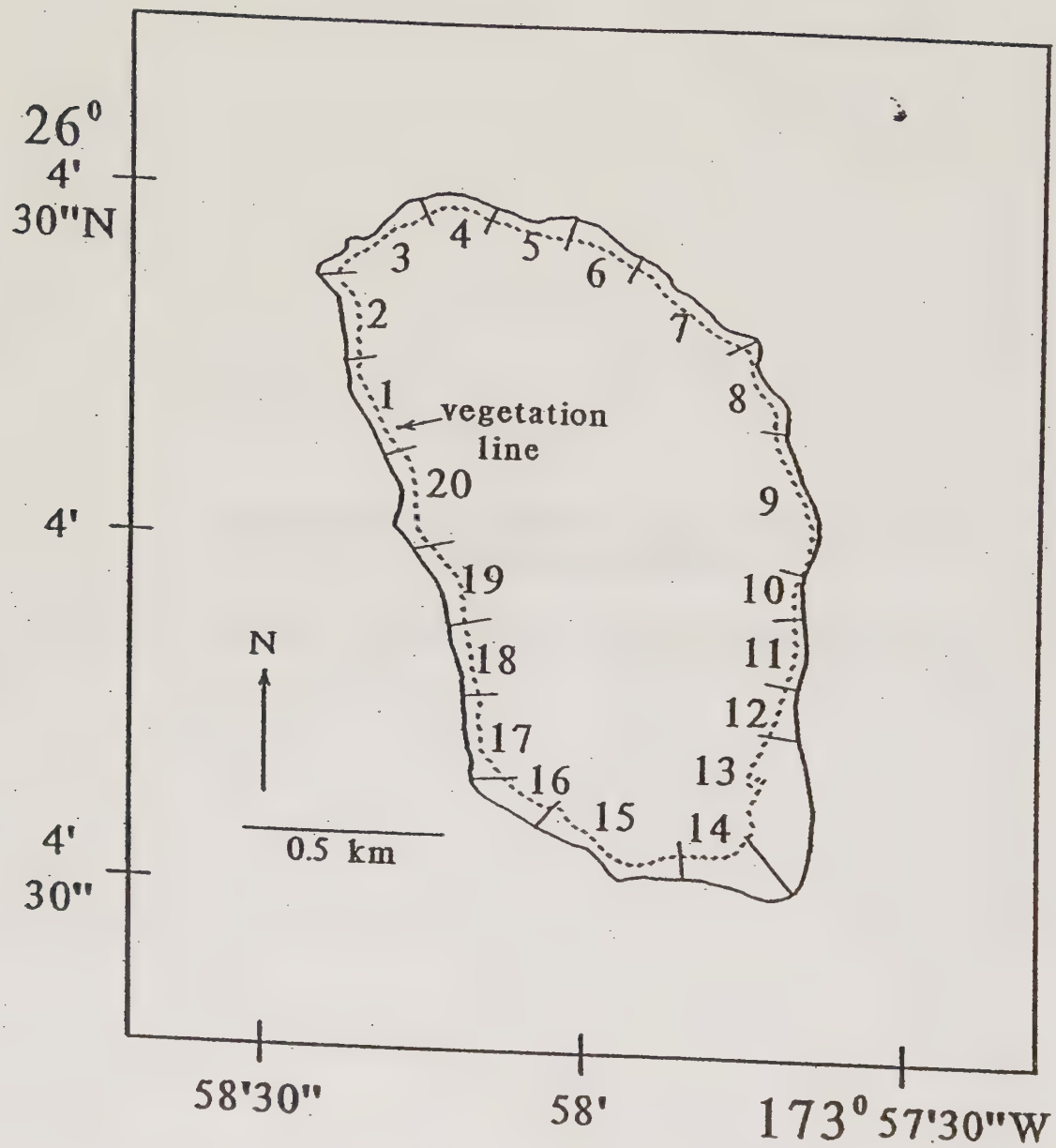

Fig. 4.1 Lisianski Island in the Northwestern Hawaiian Islands.

Lisianski Island (lat. 26°02'N, long. 174°00'W) is one of the primary haulout and pupping locations of the Hawaiian monk seal. The island is located ca. 1,760 km northwest of Oahu (Fig. 1.1) and is surrounded by Neva Shoal, a shallow reef bank within the Hawaiian Islands National Wildlife Refuge (Fig. 4.1).

RESEARCH

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at Lisianski Island in 1981. In 2002, research was conducted by NMFS during March 22–July 19. The perimeter of the island was divided into 20 sectors using artificial or natural landmarks (Fig. 4.1). Research activities specific to this subpopulation in 2002 included (1) assessment of maternity and pup exchanges and (2) documentation of adult male behavior and aggression, including focal observations in areas frequented by weaned pups.

Censuses and Patrols

Censuses, patrols and incidentals were scheduled to ensure that the entire island was monitored at least once daily during March 22–July 19. Censuses (n = 25) were conducted by two observers every fourth day from April 15 to July 19, beginning at 1300 Hawaii Standard Time and continuing from 1.5 to 2.4 h.

Standardized behavior patrols were conducted on noncensus days to assess behavior of adults and large subadults, including male aggression. During these patrols (n = 53), attention was directed out to sea as much as possible, as multiple male aggression has been observed most frequently in the water.

Full island standardized incidental surveys (n = 24) were conducted on noncensus and non-behavior patrol days from March 22 to July 8 to record female and pup pairs, sick or injured seals, weaned pups, and molting animals. Additional partial island surveys were conducted as needed.

Individual Identification

A total of 173 individuals (148 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. All weaned pups (n = 23) were tagged with Temple tags and passive integrated transponder (PIT) tags. One prematurely weaned pup did not receive a PIT tag.

Collection of Samples

Ninety-seven scat samples were collected. Skin punches were collected from 23 seals during tagging and from five dead seals during necropsies. Necropsies were performed and tissue samples were collected from one adult male, two juvenile females, one male pup, and one female pup. Skeletal samples were collected from all five seals. Forty shed molt samples were collected from 39 individuals. Two debris items were removed from entangled animals (one adult female and one dead female pup) and brought back to Honolulu. All other potentially entangling marine debris was collected from beaches and stored in a secure location pending removal.

RESULTS

Subpopulation Abundance and Composition

The mean (±SD) of 25 censuses was 69.8 seals (±7.4) including pups and 53.4 seals (±7.5) excluding pups (Table 4.1). The total spring-summer subpopulation was 167 individuals, 142 excluding pups (Table 4.2). This number is a subset of the total identified in the calendar year. The sex ratio for older (>19 years of age) and unknown-age adults was strongly skewed toward males at ca. 1.9:1 (21 males: 11 females), whereas the ratio for younger adults (≤ 19 years of age) was at 1.0:1 (36 males: 35 females). The numbers of tagged known-age seals born at Lisianski Island during the period from 1982 to 2001, and resighted at any location in 2002, are summarized in Table 4.3.

Reproduction

A minimum of 25 pups were born at Lisianski Island in 2002: 23 were successfully weaned, 2 died prior to weaning. (Table 4.4a). Nursing periods and measurements of weaned pups are summarized in Table 4.4b. The birth rate, measured as the number of pups born divided by the number of adult-sized females in the subpopulation X 100 was 54.3% ((25/46) X 100). One birth and a weaning incident were observed. A minimum of 15 pup exchanges occurred among 25 nursing females; researchers observed one of these incidents.

Interatoll Movement

Interatoll movement was documented for 15 seals that completed a total of 27 movements between Lisianski Island and either Laysan Island or Pearl and Hermes Reef (Tables 4.5a and b).

Factors Affecting Survival

Attacks by large sharks, mounting attempts by male Hawaiian monk seals, entanglement in marine debris, emaciation, and unknown factors led to 10 life-threatening conditions, which resulted in the confirmed deaths of 5 seals and the probable death of another seal (Table 4.6). A female pup was observed entangled in debris anchored to the bottom in shallow water. The pup could not be released before it drowned. Resuscitation after release was attempted but failed. This pup's nursing mother also became entangled in debris on a separate occasion but was successfully freed with no obvious deleterious effects. In addition to the incidents included on the table, intervention by researchers was required to ensure the survival of a 2-day-old female pup caught in high surf.

ACKNOWLEDGMENTS

We acknowledge the support of the U.S. Fish and Wildlife Service, Hawaiian Islands National Wildlife Refuge staff. We thank the captain, officers, and crew of the M/V *American Islander* and the F/V *Ocean Fury* for logistical assistance.

TABLES
for Lisianski Island

Table 4.1.--Summary statistics for censuses (n = 25) of Hawaiian monk seals at Lisianski Island from April 15 to July 19, 2002.

Size/Sex	Mean number of individuals	Standard deviation
Adults	40.8	7.3
Male	19.0	4.4
Female	18.6	4.7
Unknown	3.1	2.1
Subadults	10.4	3.6
Male	6.2	2.8
Female	3.6	1.6
Unknown	0.6	0.9
Juveniles	2.3	1.3
Male	0.7	0.6
Female	1.5	1.0
Unknown	0.0	0.2
Pups	16.4	4.3
Male	8.3	2.4
Female	7.0	2.5
Unknown	1.0	1.2
Non-pup total	53.4	7.5
Grand total	69.8	7.4

Table 4.2.--Composition of the Hawaiian monk seal subpopulation at Lisianski Island during the spring and summer of 2002. Includes all known parturient females and all pups born during the calendar year.

Size	Number of seals			Sex ratio male:female
	Male	Female	Total	
Adults	57	46	103	1.2:1
Subadults	20	10	30	2.0:1
Juveniles	4	5	9	0.8:1
Pups	13	12	25	1.1:1
Non-pup total	81	61	142	1.3:1
Grand total	94	73	167	1.3:1

Table 4.3.--Summary of tagged known-age seals born at Lisianski Island and resighted at any location in 2002.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2002
1982	20	Male	7	2
		Female	6	0
1983		Male	6	2
	19	Female	18	7
1984	18	Male	10	4
		Female	5	1
1985	17	Male	5	1
		Female	9	1
1986	16	Male	11	5
		Female	9	3
1987	15	Male	12	1
		Female	6	1
1988	14	Male	10	5
		Female	8	6
1989	13	Male	--	--
		Female	--	--
1990	12	Male	8	4
		Female	9	3
1991	11	Male	9	4
		Female	6	2
1992	10	Male	13	6
		Female	8	4
1993	9	Male	4	2
		Female	9	2
1994	8	Male	4	1
		Female	5	1
1995	7	Male	7	2
		Female	10	2
1996	6	Male	9	2
		Female	13	1
1997	5	Male	10	5
		Female	9	3

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2002
1998	4	Male	10	3
		Female	11	4
1999	3	Male	16	5
		Female	11	2
2000	2	Male	9	1
		Female	9	2
2001	1	Male	5	2
		Female	9	3

Table 4.4a.--Summary of Hawaiian monk seals born at Lisianski Island in 2002.

Event	Number of pups		
	Male	Female	Total
Born	13	12	25
Died/Probably died prior to weaning	1	1	2
Weaned	12	11	23
Tagged	12	11	23

Table 4.4b.--Summary of nursing periods and measurements of weaned pups at Lisianski Island in 2002. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	34.5	100.0	123.1
Standard deviation	6.4	11.6	7.9
n	23	22	22

Table 4.5a.–Documented movement of Hawaiian monk seals to Lisianski Island from other locations in 2002, summarized by movements between two locations. No seals made more than one observed trip.

Original location	Number of trips, size, and sex class
Laysan Island	1 adult male 7 adult female 2 subadult male 2 subadult female

Table 4.5b.–Documented movement of Hawaiian monk seals from Lisianski Island to other locations in 2002, summarized by movements between two locations. One seal made more than one observed trip.

Destination	Number of trips, size, and sex class
Laysan Island	2 adult male 9 adult female 1 subadult male 2 subadult female
Pearl and Hermes Reef	1 adult female

Table 4.6.--Factors affecting Hawaiian monk seal survival at Lisianski Island in 2002.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
Attack by Large Shark					
Adult	Male	1	1	0	0
	Female	1	1	0	0
Mounting by Male					
Adult	Female	1	1	0	0
Entanglement					
Adult	Female	1[a]	0	0	0
Nursing pup	Female	1	0	1[b]	0
Emaciation					
Adult	Male	1	0	1[c]	0
Juvenile	Female	2	0	2[d]	0
Prematurely weaned pup	Male	1	0	0	1[e]
Unknown					
Nursing pup	Male	1	0	1	0

[a] Seal released by observers.
[b] Drowned from entanglement in approximately 1 m of water.
[c] Emaciated, also injured by a minor shark bite prior to death.
[d] One seal developed an abscess prior to death.
[e] Pup was prematurely weaned after 18 days and became severely emaciated prior to disappearance.

CHAPTER 5. THE HAWAIIAN MONK SEAL ON PEARL AND HERMES REEF, 2002

Chad Yoshinaga, Maire Cahoon, Tracy Wurth, and Molly Timmers

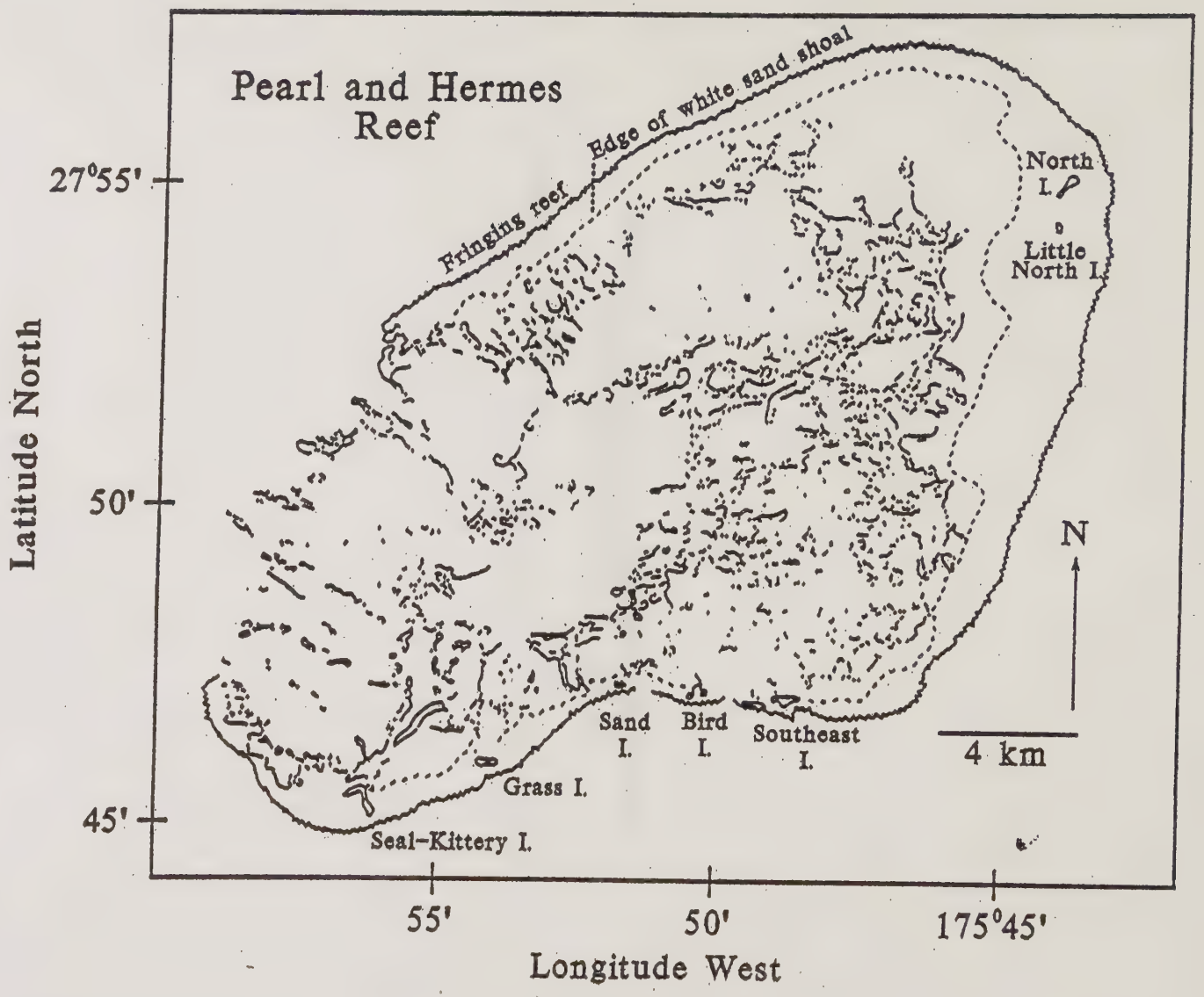

Fig. 5.1 Pearl and Hermes Reef in the Northwestern Hawaiian Islands.

Pearl and Hermes Reef (lat. 27°55'N, long. 175°45'W) is one of the primary haulout and pupping locations of the Hawaiian monk seal. This atoll is located ca. 1,900 km northwest of Oahu in the Northwestern Hawaiian Islands and is part of the Hawaiian Islands National Wildlife Refuge (Fig. 1.1). Pearl and Hermes is composed of four vegetated and three nonvegetated sand islets enclosed in a barrier reef (Fig. 5.1).

RESEARCH

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at Pearl and Hermes Reef in 1982. In 2002, research was conducted by NMFS during May 18–July 19. The perimeters of the four larger vegetated islets were divided into sectors using natural landmarks. Research activities specific to this subpopulation in 2002 included opportunistic patrols of the north-northeast emergent reef to identify seals using the reef as haulout areas.

Censuses and Patrols

Atoll censuses ($n = 8$) were conducted once a week, on average, from June 1 to July 19. Each atoll census began around 1000 and ended around 1700 Hawaii Standard Time. All islets were censused on foot by one or two persons. In addition, incidental patrols were conducted opportunistically on each island and the emergent reef to resight seals tagged in previous years and to identify and bleach-mark animals.

Individual Identification

A total of 226 individuals (196 excluding pups) were identified by existing or applied tags, scars, or natural markings. Seventy-three seals were marked with bleach and 57 seals were resighted with active applied bleach marks. Twenty-two weaned pups were tagged with Temple Tags and passive integrated transponder (PIT) tags.

Collection of Samples

Sixty-three scat samples were collected between May 19 and July 11. Skin punches were collected from 18 seals during tagging. Two skeletal samples and four necropsy tissue samples were collected. All potentially entangling marine debris was collected from beaches and stored in a secure location pending removal.

Emergent Reef Surveys

In 2002, incidental patrols were conducted along the north-northeast emergent reef. The approximately 5 miles (8 km) of exposed reef were surveyed in approximately 2.5 h. Patrols were done by kayak, which allowed biologists to navigate through the shallow waters near the emergent reef and get close to seals on the reef to determine their identity. A motor-powered boat served as safety/backup and followed the kayaker during the patrol.

Four reef surveys were conducted from June 9 to July 4, starting at approximately 1000. A total of 20 animals were sighted on the reef. Of the 20 animals, 15 were adults, 4 were subadults, and 1 was a weaned pup.

RESULTS

Subpopulation Abundance and Composition

The mean (±SD) of 8 atoll censuses was 85.0 seals (±10.1) including pups and 70.1 seals (±9.8) excluding pups (Table 5.1). The total number of seals identified as part of the summer subpopulation was 222 individuals, 192 excluding pups (Table 5.2). This number is a subset of the total identified in the calendar year. The numbers of tagged known-age seals born at Pearl and Hermes Reef during the period from 1983 to 2001 and resighted at any location in 2002 are summarized in Table 5.3.

Reproduction

At least 30 pups were born at Pearl and Hermes Reef in 2002: 23 were successfully weaned, 2 died prior to weaning, and 5 were still nursing at the end of the research period (Table 5.4). The minimum number of pups born divided by the number of adult-sized females identified in the subpopulation X 100, was 45.5% ((30/66) X 100). Nursing periods and measurements of weaned pups are summarized in Table 5.4. Two of the 19 identified parturient females (10.5%) were involved in past management efforts; 1 had been temporarily maintained as a pup in the Kure Atoll Head Start enclosure in 1990, and 1 was a rehabilitated seal from French Frigate Shoals, introduced to Kure as a yearling in 1993.

Interatoll Movement

Interatoll movement was documented for 10 seals that completed a total of 12 movements between Pearl and Hermes Reef and either Lisianski Island, Midway Atoll, or Kure Atoll (Tables 5.5a and b).

Factors Affecting Survival

Mounting attempts by male Hawaiian monk seals, entanglement in marine debris, emaciation, and unknown factors led to nine life-threatening conditions, which resulted in the confirmed deaths of eight seals (three adults, one subadult, one juvenile, one weaned pup, and two nursing pups). The carcass of a weaned female pup with severe mounting injuries was observed being actively mounted and defended by an unidentified adult male. Seals were observed basking on and investigating debris, and one weaned pup was found entangled in marine debris and subsequently released by observers (Table 5.6). In addition to the incidents included in Table 5.6, two seals were observed with minor wounds and one subadult male seal was observed with a clouded right eye. No major shark-related injuries were observed.

ACKNOWLEDGMENTS

We thank the captain, officers, and crew of the NOAA ship *Townsend Cromwell*. We also acknowledge the support of the NMFS Coral Reef Ecological Investigation Debris Program, U.S. Fish and Wildlife Service, and Hawaiian Islands National Wildlife Refuge staff.

TABLES
for Pearl and Hermes Reef

Table 5.1.--Summary statistics for atoll censuses (n = 8) of the Hawaiian monk seal at Pearl and Hermes Reef from June 1 to July 19, 2002.

Size/Sex	Mean number of individuals	Standard deviation
Adults	51.3	9.4
Male	19.9	5.6
Female	26.3	4.3
Unknown	5.1	2.8
Subadults	12.8	3.8
Male	5.8	3.0
Female	5.9	1.9
Unknown	1.1	1.0
Juveniles	5.5	1.6
Male	3.5	1.2
Female	1.9	1.1
Unknown	0.1	0.4
Pups	14.9	3.8
Male	9.4	3.0
Female	2.8	1.8
Unknown	2.8	1.4
Non-pup total[a]	70.1	9.8
Grand total[a]	85.0	10.1

[a] The total includes some seals that were not placed in any size class.

Table 5.2.– Composition of the Hawaiian monk seal subpopulation at Pearl and Hermes Reef during the spring and summer of 2002. These numbers are an unknown proportion of the entire subpopulation. Includes all known parturient females and pups born during the calendar year.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	68	66	5	139	1.0:1
Subadults	14	17	2	33	0.8:1
Juveniles	12	7	1	20	1.7:1
Pups	18	7	5	30	2.6:1
Non-pup total	94	90	8	192	1.0:1
Grand total	112	97	13	222	1.2:1

Table 5.3.--Summary of tagged known-age seals born at Pearl and Hermes Reef and resighted at any location in 2002.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2002
1983	19	Male	8	1
		Female	2	1
1984	18	Male	5	2
		Female	8	3
1985	17	Male	9	2
		Female	6	4
1986	16	Male	10	2
		Female	7	2
		Unknown	1	0
1987	15	Male	14	4
		Female	7	2
1988	14	Male	12	8
		Female	6	3
1989	13	Male	8	2
		Female	6	1
1990	12	Male	5	2
		Female	1	0
1991	11	Male	10	7
		Female	11	5
1992	10	Male	13	6
		Female	10	7
1993	9	Male	14	5
		Female	7	4
1994	8	Male	--	--
		Female	--	--
1995	7	Male	15	8
		Female	12	5
1996	6	Male	11	2
		Female	12	5
1997	5	Male	16	7
		Female	11	5

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2002
1998	4	Male	8	4
		Female	21	12
1999	3	Male	11	6
		Female	15	5
2000	2	Male	12	6
		Female	10	2
2001	1	Male	16	3
		Female	9	3

Table 5.4a.--Summary of Hawaiian monk seals born at Pearl and Hermes Reef in 2002.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	18	7	5	30
Died prior to weaning	0	0	2	2
Still nursing	2	0	3	5
Weaned	16	7	0	23
Tagged	16	6	0	22

Table 5.4b.--Summary of nursing periods and measurements of weaned pups at Pearl and Hermes Reef in 2002. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	20.8	106.5	129.1
Standard deviation	6.0	8.5	9.5
n	2[a]	10	10

[a] Both pups weaned prematurely.

Table 5.5a.–Documented movement of Hawaiian monk seals to Pearl and Hermes Reef from other locations in 2002, summarized by movements between two locations. No seals made more than one observed trip.

Original location	Number of trips, size, and sex class
Lisianski Island	1 adult female
Midway Atoll	3 adult male 2 adult female
Kure Atoll	1 adult female

Table 5.5b.–Documented movement of Hawaiian monk seals from Pearl and Hermes Reef to other locations in 2002, summarized by movements between two locations. No seals made more than one observed trip.

Destination	Number of trips, size, and sex class
Midway Atoll	1 adult male 2 adult female
Kure Atoll	1 adult female 1 subadult male

Table 5.6.--Factors affecting Hawaiian monk seal survival at Pearl and Hermes Reef in 2002.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
Attack by Large Shark					
(none observed)					
Mounting by Male					
Weaned pup	Female	1[a]	0	1	0
Entanglement					
Weaned pup	Female	1[b]	0	0	0
Emaciation					
Adult	Male	1	0	1	0
Unknown					
Adult	Male	2	0	2	0
Subadult	Female	1	0	1	0
Juvenile	Male	1	0	1	0
Nursing pup	Unknown	2	0	2	0

[a] Carcass of pup with severe mounting injuries was being actively mounted and defended by an adult male when found.

[b] Seal released by observers.

CHAPTER 6. THE HAWAIIAN MONK SEAL ON MIDWAY ATOLL, 2002

Leona Laniawe and Amanda Del Bene

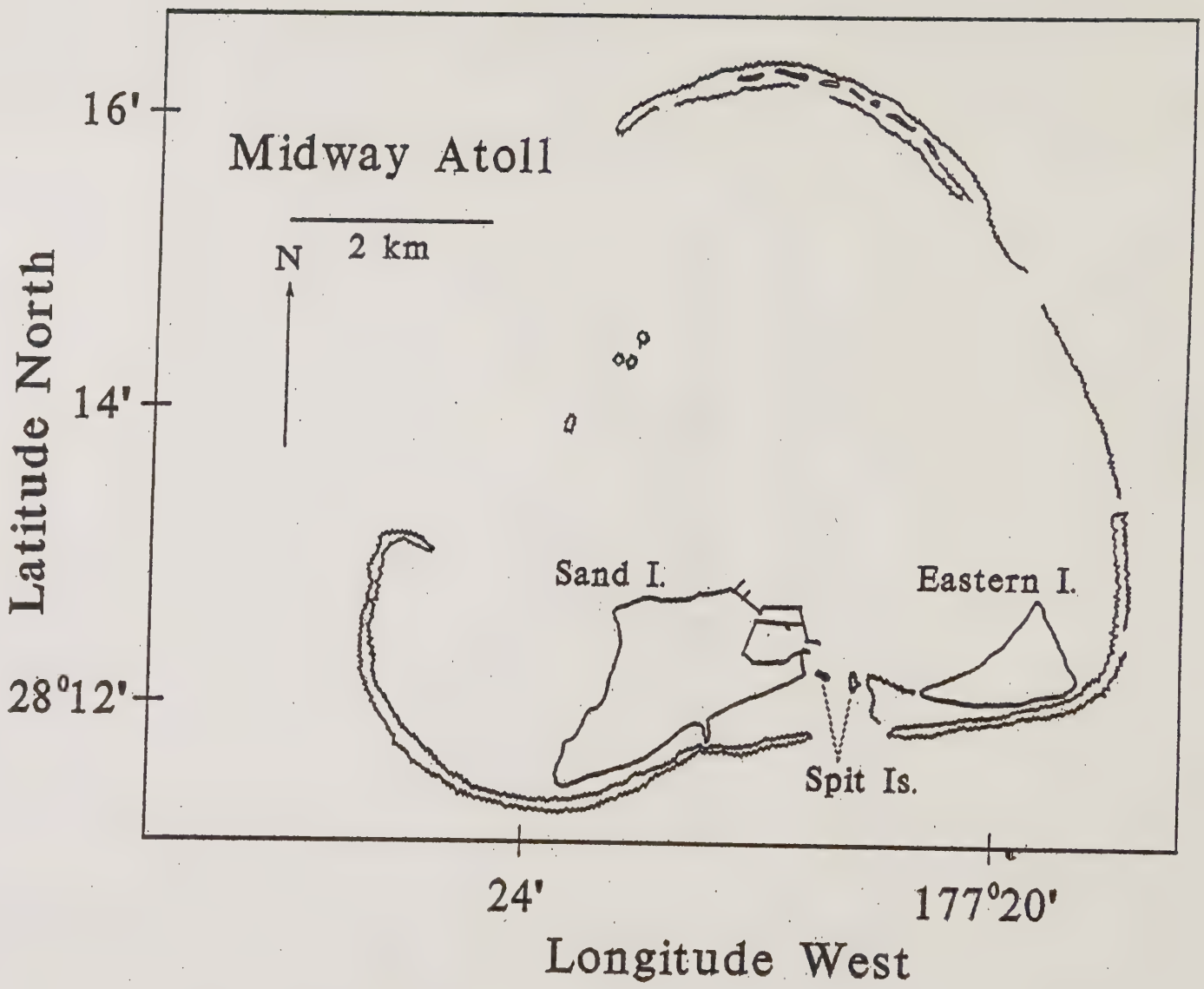

Fig. 6.1 Midway Atoll in the Northwestern Hawaiian Islands.

Midway Atoll (lat. 28°14'N, long. 177°22'W) is one of the primary haulout and pupping locations of the endangered Hawaiian monk seal. This atoll is located ca. 2,100 km northwest of Oahu in the Northwestern Hawaiian Islands (Fig. 1.1) and comprises a circular atoll approximately 9 km in diameter, enclosing a lagoon and three permanent islets (Fig. 6.1). Eastern and Spit Islands are uninhabited. Sand Island was the site of a U.S. Naval Air base from ca. 1939 until 1993. The U.S. Fish and Wildlife Service (USFWS) maintained an overlay refuge (Midway Atoll National Wildlife Refuge) at the site from 1988, until full authority was transferred to the USFWS in October 1996.

RESEARCH

The National Marine Fisheries Service (NMFS) began limited monitoring of Hawaiian monk seals at Midway Atoll in 1983. This effort was increased to year-round monitoring during 1997-1999 by collaborating researchers from Oceanic Society (OS) and Hawaii Wildlife Fund. In 2002, research was conducted by NMFS during March 22–July 22. Incidental observations were recorded by USFWS and OS personnel during January–March 21. Perimeters of the three permanent islets were divided into sectors using artificial or natural landmarks. Research activities specific to this subpopulation in 2002 included (1) emergent reef surveys to determine haulout patterns on these areas and (2) survey for and removal of marine debris from the north and east reef flats and emergent reef areas.

Censuses and Patrols

Atoll censuses (n = 18) were conducted every sixth day, on average, from March 26 to July 15. Each atoll census began between 0832 and 1653, and ended between 0927 and 1740 Hawaii Standard Time. All islets were censused on foot by one or two persons. Spit Island was occasionally surveyed by boat on severe weather days. Patrols of Sand Island (n = 25), Eastern I. (n = 31), or Spit I. (n = 19) were conducted on nonatoll census days during January 1–July 22.

Individual Identification

Seventy-four individuals (61 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. Eleven pups weaned at Midway were tagged with Temple tags and passive integrated transponder (PIT) tags.

Collection of Samples

Skin punches were collected from 11 weaned pups during tagging. Five scats, 94 ticks, 1 entangling debris, and 11 shed molt samples were collected. One necropsy was performed and tissue samples were collected. All potentially entangling marine debris was collected from beaches and either destroyed at Midway or stored on Midway pending removal.

Special Studies

Emergent Reef Surveys

Patrols were conducted along the emergent reef areas of the North Reef ($n = 3$) and East Reef ($n = 3$) from June 19 to July 2, 2002. Two persons using kayaks and a motorboat surveyed the reefs for seals and turtles. On all occasions, the two emergent reef areas were surveyed within 1 day of atoll counts to provide an estimate of atoll-wide beach/emergent reef counts.

Noteworthy Events

Beach Monitoring and Public Education

From March to July 2002, Sand Island beaches were monitored for approximately 10 h/week. In addition incidental patrols were conducted on public access beaches when ships and planes were scheduled to arrive. Monk seal natural history was shared opportunistically with visitors and residents. Other actions included the posting of signs approximately 50 yards away from seals in accessible areas to help people avoid disturbing the seals.

Pupping and Perinatal Death After Shark Attack

On April 1, 2002, an injured, pregnant monk seal was observed on the boat ramp on Sand Island. The wounds were attributed to a large shark. The seal was videotaped giving birth to a stillborn pup. The female was originally a rehabilitated pup born at French Frigate Shoals and released in 1991 as a yearling at Kure Atoll.

RESULTS

Subpopulation Abundance and Composition

The mean (±SD) of 18 atoll censuses was 23.8 seals (±4.6) including pups and 18 seals (±4.2) excluding pups (Table 6.1). The total spring-summer subpopulation was 62

seals, 49 excluding pups (Table 6.2). This number is a subset of the total identified in the calendar year. The numbers of tagged known-age seals born at Midway Atoll during the period from 1988 to 2001, and resighted at any location in 2002, are summarized in Table 6.3.

Reproduction

A minimum of 13 pups were born at Midway Atoll in 2002, 11 successfully weaned and 2 died prior to weaning (Table 6.4a). The birth rate, measured as the number of pups born divided by the number of adult-sized females in the subpopulation X 100 was 61.9% ((13/21) X 100). A minimum of one pup exchange occurred between nursing females, but they ended up with their original pups within the half hour. Nursing periods and measurements of weaned pups are summarized in Table 6.4b. Five of the 12 identified parturient females (41.7%) were involved in past management actions; 4 were rehabilitated seals from French Frigate Shoals introduced to Kure as yearlings (2 each in 1991 and 1993), and 1 was a rehabilitated seal from Kure Atoll reintroduced to Kure as a yearling in 1988).

Interatoll Movement

Interatoll movement was documented for 19 seals that completed a total of 31 movements between Midway Atoll and either Pearl and Hermes Reef or Kure Atoll (Tables 6.5a and b).

Factors Affecting Survival

Attacks by sharks, entanglement in marine debris, emaciation, and other/unknown factors led to 15 life-threatening conditions, which resulted in the confirmed death of 4 animals and the probable death of 2 additional seals (Table 6.6). An adult female was found dead due to shark related injuries, and one of the two perinatal pup deaths occurred immediately after the pup's mother received severe shark injuries. The cause of the other two deaths was unknown. In addition, two emaciated yearlings disappeared and probably died, including one that disappeared after receiving severe wounds attributed to a large shark. Two seals were entangled in marine debris: an adult female escaped unaided, and another adult female was released by observers.

ACKNOWLEDGMENTS

We acknowledge the support of the U.S. Fish and Wildlife Service and Oceanic Society. Special thanks are extended to John Klavitter, Refuge Biologist; Mike Johnson, Assistant Refuge Manager; and Tim Bodeen, Refuge Manager. We also thank the officers and crew of the NOAA ship *Townsend Cromwell* for logistical assistance.

TABLES
for Midway Atoll

Table 6.1.--Summary statistics for atoll censuses (n = 18) of Hawaiian monk seals at Midway Atoll from March 26 to July 15, 2002.

Size/Sex	Mean number of individuals	Standard deviation
Adults	9.7	2.7
Male	1.6	1.8
Female	7.7	1.7
Unknown	0.4	0.7
Subadults	5.2	2.4
Male	2.8	1.8
Female	2.1	0.9
Unknown	0.3	0.6
Juveniles	3.1	1.3
Male	2.2	1.2
Female	0.8	0.4
Unknown	0.1	0.2
Pups	5.8	2.3
Male	2.2	1.9
Female	0.9	1.1
Unknown	2.7	1.8
Non-pup total	18.0	4.2
Grand total	23.8	4.6

Table 6.2.--Composition of the Hawaiian monk seal subpopulation at Midway Atoll during the spring and summer of 2002. Includes all known parturient females and pups born during the calendar year.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	7	21	0	28	0.3:1
Subadults	8	7	0	15	1.1:1
Juveniles	5	1	0	6	5.0:1
Pups	7	4	2	13[a]	1.8:1
Non-pup total	20	29	0	49	0.7:1
Grand total	27	33	2	62	0.8:1

[a] Includes two perinatal pup deaths.

Table 6.3.--Summary of tagged known-age seals born at Midway Atoll and resighted at any location in 2002.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2002
1988	14	Male	0	NA
		Female	1	1
1989	13	Male	0	NA
		Female	0	NA
1990	12	Male	0	NA
		Female	0	NA
1991	11	Male	1	1
		Female	1	1
1992	10	Male	0	NA
		Female	1	1
1993	9	Male	1	0
		Female	0	NA
1994	8	Male	0	NA
		Female	0	NA
1995	7	Male	1	0
		Female	6	1
		Unknown	1	0
1996	6	Male	1	0
		Female	4	0
1997	5	Male	3	1
		Female	6	2
1998	4	Male	8	3
		Female	2	2
1999	3	Male	7	2
		Female	4	1
2000	2	Male	5	1
		Female	9	0
2001	1	Male	6	4
		Female	5	3

Table 6.4a.--Summary of Hawaiian monk seals born at Midway Atoll in 2002.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	7	4	2	13
Died prior to weaning	0	0	2	2[a]
Weaned	7	4	0	11
Tagged	7	4	0	11

[a] Two perinatal pup deaths. Includes a pup born to a female with fresh, severe shark injuries.

Table 6.4b.--Summary of nursing periods and measurements of weaned pups at Midway Atoll in 2002. Nursing periods were calculated when birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	36.7	111.3	127.2
Standard deviation	2.1	9.1	3.1
n	8	11	11

Table 6.5a.–Documented movement of Hawaiian monk seals to Midway Atoll from other locations in 2002, summarized by movements between two locations. One seal made more than one observed trip.

Destination	Number of trips, size, and sex class
Pearl and Hermes Reef	1 adult male 2 adult female
Kure Atoll	3 adult male 4 adult female 3 subadult male

Table 6.5b.–Documented movement of Hawaiian monk seals from Midway Atoll to other locations in 2002, summarized by movements between two locations. One seal made more than one observed trip.

Destination	Number of trips, size, and sex class
Pearl and Hermes Reef	3 adult male 2 adult female
Kure Atoll	4 adult male 7 adult female 1 subadult male 1 subadult female

Table 6.6.--Factors affecting Hawaiian monk seal survival at Midway Atoll in 2002.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
Attack by Large Shark					
Adult	Female	6	5	1	0
Subadult	Male	1	1	0	0
	Female	1	1	0	0
Juvenile	Male	1	0	0	1[a]
Mounting by Males (none observed)					
Entanglement					
Adult	Female	2[bc]	0	0	0
Emaciation					
Juvenile	Male	1	0	0	1
Other/Unknown					
Juvenile	Male	1	0	1[d]	0
Nursing pup	Unknown	2	0	2[e]	0

[a]Seal emaciated prior to shark attack.
[b]Seal freed itself.
[c]Seal released by researchers.
[d]Found dead in September 2002.
[e]Perinatal pup deaths. One mother pupped/aborted her full-term pup immediately after sustaining a major shark injury.

CHAPTER 7. THE HAWAIIAN MONK SEAL ON KURE ATOLL, 2002

Erin E. Moreland and Stephanie A. Vlachos

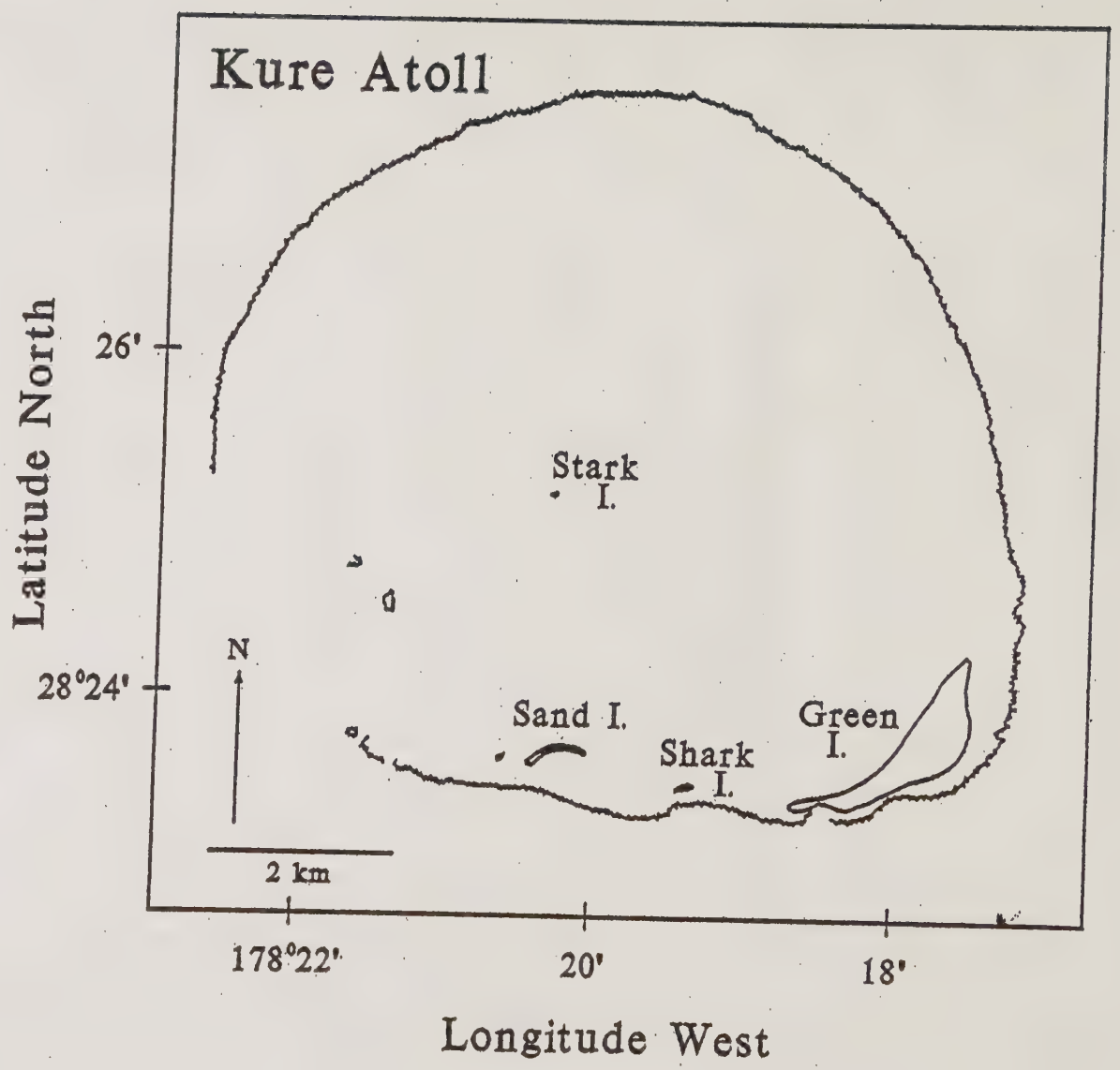

Fig. 7.1 Kure Atoll in the Northwestern Hawaiian Islands.

Kure Atoll (lat. 28°25'N, long. 178°10'W) is one of the primary haulout and pupping locations of the Hawaiian monk seal. The atoll is located ca. 2,300 km northwest of Oahu in the Northwestern Hawaiian Islands (Fig. 1.1) and is a seabird sanctuary of the State of Hawaii. The atoll consists of a circular barrier reef approximately 9 km in diameter, the enclosed lagoon, one permanent vegetated island (Green Island), two sand islets (Sand and Shark), and an ephemerally emergent area known locally as Stark Reef (Fig. 7.1). From 1960 to 1992, Green Island was the site of a U.S. Coast Guard (USCG) LORAN station staffed by 20–30 USCG personnel. In July 1992, this station was closed and vacated by the USCG, leaving the atoll uninhabited. In 1993, the USCG completed the removal of most of the infrastructure on Green Island.

RESEARCH

National Marine Fisheries Service (NMFS) began research on the Hawaiian monk seal at Kure Atoll in 1981. In 2002, research was conducted by NMFS from May 16 to July 21. The perimeter of Green Island was divided into eight sectors using artificial or natural landmarks. Research objectives specific to this subpopulation in 2002 included (1) identification of all seals using the atoll and (2) monitoring seals equipped with satellite-linked dive recorders (SLDRs) in 2001 and recovering these instruments.

Censuses and Patrols

Atoll censuses (n = 14) were conducted every third day on average, from May 30 to July 15. Each census began between 1300 and 1333 and ended between 1531 and 1635 Hawaii Standard Time. All islets were censused on foot by one or two persons. Shark Islet and Stark Reef were not emergent during the 2002 field season.

Patrols were conducted on nonatoll census days to identify seals and monitor locations used by parturient females. In total, 32 patrols of Green Island and 1 patrol of Sand Islet were conducted.

Individual Identification

A total of 120 individuals (101, excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. Most weaned pups (n = 18) were tagged with Temple Tags and passive integrated transponder (PIT) tags. One prematurely weaned pup was not captured for tagging.

Collection of Samples

Seventy-one scat and two spew samples were collected. Skin punches were collected from 18 seals during tagging. One necropsy was performed and 20 tissue samples were collected from one juvenile female. Approximately 50 bird ticks were also collected. Two samples were collected from a net aggregate (estimated 75 lb) found with two drowned fish including a small shark and an amberjack. An entangled wrasse was released alive from this aggregate. All other potentially entangling marine debris was collected from beaches and stored in a secure location pending removal. To minimize entanglement hazard, emergent net and line were removed from two large conglomerates (one net and one line estimated >500 lb each) that remain buried on Green Island. These conglomerates are located within and near a large portion of the *Paradise Queen II* wheel house on the east shore of Green Island. An unstable section of deck and hull remains on the reef and was frequented regularly by one nursing pair of seals and several weaned pups in the area. A small line aggregate (approximately 10 lb) was removed from the hull.

Special Studies

Foraging Ecology

Eighteen of the 24 seals equipped with SLDRs in October and November 2001 were sighted during the 2002 field season. All of the instrumented seals not seen were juveniles. Seven satellite tags were lost throughout the season, including one recovered from a dead female yearling.

RESULTS

Subpopulation Abundance and Composition

The mean (±SD) of 14 atoll censuses was 43.7 seals (±5.4) including pups and 35.2 seals (±5.2) excluding pups (Table 7.1). The total number of seals identified as part of the spring-summer subpopulation was 114 individuals, 95 excluding pups (Table 7.2). This number is a subset of the total identified in the calendar year. The numbers of tagged known-age seals born at Kure Atoll during the period from 1981 to 2001, and resighted at any location in 2002, are summarized in Table 7.3.

Reproduction

At least 19 pups were born at Kure Atoll in 2002, and 18 successfully weaned. One pup weaned prematurely and disappeared 5 weeks later (Table 7.4a). Nursing periods and measurements of weaned pups are summarized in Table 7.4b. The birth rate, measured as the minimum number of pups born divided by the number of adult-sized females identified in the subpopulation X 100 was 50.0% ((19/38 X 100). Seven of the eight identified parturient females (87.5%) were involved in past management efforts; five had been

temporarily maintained as pups in the Kure Atoll Head Start Project (one in 1985, and two each in 1988 and 1991), and three were rehabilitated seals from FFS introduced to Kure as yearlings via the Head Start enclosure (one each in 1984 and 1989).

Interatoll Movement

Interatoll movement was documented for 17 seals that completed a total of 27 movements between Kure Atoll and Laysan Island, Pearl and Hermes Reef, or Midway Atoll (Table 7.5).

Factors Affecting Survival

Attacks by large sharks, mounting attempts by male Hawaiian monk seals, entanglement in marine debris, emaciation, and other factors led to six life-threatening conditions, which resulted in the confirmed death of one seal and the probable death of another seal. One emaciated female yearling was found dead on May 18, and a male pup, prematurely weaned at approximately 1 week old, disappeared 5 weeks later on June 27 and is presumed dead. One adult female in thin condition recovered from a dorsal abscess possibly resulting from an adult male seal-inflicted injury. A female subadult freed herself from a broken plastic jug around her head and neck.

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TABLES
for Kure Atoll

Table 7.1.--Summary statistics for atoll censuses (n = 14) of Hawaiian monk seals at Kure Atoll from May 30 to July 15, 2002.

Size/Sex	Mean number of individuals	Standard deviation
Adults	28.1	4.5
Male	10.5	2.8
Female	12.2	2.2
Unknown	5.4	2.7
Subadults	5.6	1.8
Male	2.6	1.5
Female	2.4	1.7
Unknown	0.6	0.8
Juveniles	1.5	1.0
Male	1.0	0.8
Female	0.3	0.5
Unknown	0.2	0.4
Pups	8.5	2.9
Male	6.0	2.2
Female	2.4	0.9
Unknown	0.1	0.4
Non-pup total	35.2	5.2
Grand total	43.7	5.4

Table 7.2.--Composition of the Hawaiian monk seal subpopulation at Kure Atoll during the spring and summer of 2002. These numbers are an unknown proportion of the entire subpopulation. Includes all known parturient females and pups born during the calendar year.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	35	38[a]	1	73	0.9:1
Subadults	8	4	0	13	1.6:1
Juveniles	2	5	0	7	0.4:1
Pups	12[b]	7	0	19	1.7:1
Non-pup total	45	47	1	93	1.0:1
Grand total	57	54	1	112	1.1:1

[a] Number includes 20 individuals involved in management programs (Head Start, Rehabilitation, and Translocation).

[b] Number includes one prematurely weaned pup, presumed dead.

Table 7.3.--Summary of tagged known-age seals born at Kure Atoll and resighted at any location in 2002.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2002
1981	21	Male	3	2
		Female	5	0
1982	20	Male	1	0
		Female	3	2
1983	19	Male	4	2
		Female	0	NA
1984	18	Male	4	0
		Female	2	2
1985	17	Male	2	1
		Female	3	2
1986	16	Male	1	0
		Female	0	NA
1987	15	Male	1	0
		Female	3	3[a]
1988	14	Male	2	2
		Female	5	2
1989	13	Male	5	1
		Female	4	1
1990	12	Male	3	0
		Female	3	2
1991	11	Male	7	4
		Female	6	3[a]
1992	10	Male	5	3
		Female	8	5
1993	9	Male	9	5
		Female	4	2
1994	8	Male	3	0
		Female	0	NA
1995	7	Male	6	4
		Female	5	2
1996	6	Male	10	3
		Female	6	0

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2002
1997	5	Male	9	1
		Female	7	3
1998	4	Male	17	6
		Female	6	3
1999	3	Male	8	2
		Female	13	3
2000	2	Male	5	1
		Female	8	0
2001	1	Male	4	1
		Female	13	2

[a] Cohort survivors include seals removed from Kure Atoll for rehabilitation. These seals ($n = 2$) were released at Kure or Midway Atoll.

Table 7.4a.--Summary of Hawaiian monk seals born at Kure Atoll in 2002.

Event	Number of pups		
	Male	Female	Total
Born	12	7	19
Died prior to weaning	0	0	0
Weaned	12	7	19
Tagged	11	7	18

Table 7.4b.--Summary of nursing periods and measurements of weaned pups at Kure Atoll in 2002. Nursing periods were calculated when birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	40.5	109.6	128.9
Standard deviation	--	13.2	10.4
n	1	8	8

Table 7.5a.–Documented movement of Hawaiian monk seals to Kure Atoll from other locations in 2002, summarized by movements between two locations. One seal made more than one observed trip.

Original location	Number of trips, size, and sex class
Laysan Island	1 adult female
Pearl and Hermes Reef	1 adult female 1 subadult male
Midway Atoll	4 adult male 7 adult female 1 subadult male 1 subadult female

Table 7.5b.–Documented movement of Hawaiian monk seals from Kure Atoll to other locations in 2002, summarized by movements between two locations. One seal made more than one observed trip.

Destination	Number of trips, size, and sex class
Pearl and Hermes Reef	1 adult female
Midway Atoll	3 adult male 4 adult female 3 subadult male

Table 7.6.--Factors affecting Hawaiian monk seal survival at Kure Atoll in 2002.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
Attack by Large Shark					
Adult	Male	2	2	0	0
Mounting by Males					
Adult	Female	1	1	0	0
Entanglement					
Subadult	Female	1[a]	0	0	0
Emaciation					
Juvenile	Female	1	0	1	0
Other					
Prematurely weaned	Male	1	0	0	1[b]

[a] Seal disentangled self.

[b] Prematurely weaned at approximately 1 week of age, became emaciated, and disappeared.

CHAPTER 8. THE HAWAIIAN MONK SEAL ON NIHOA AND NECKER ISLANDS, 2002

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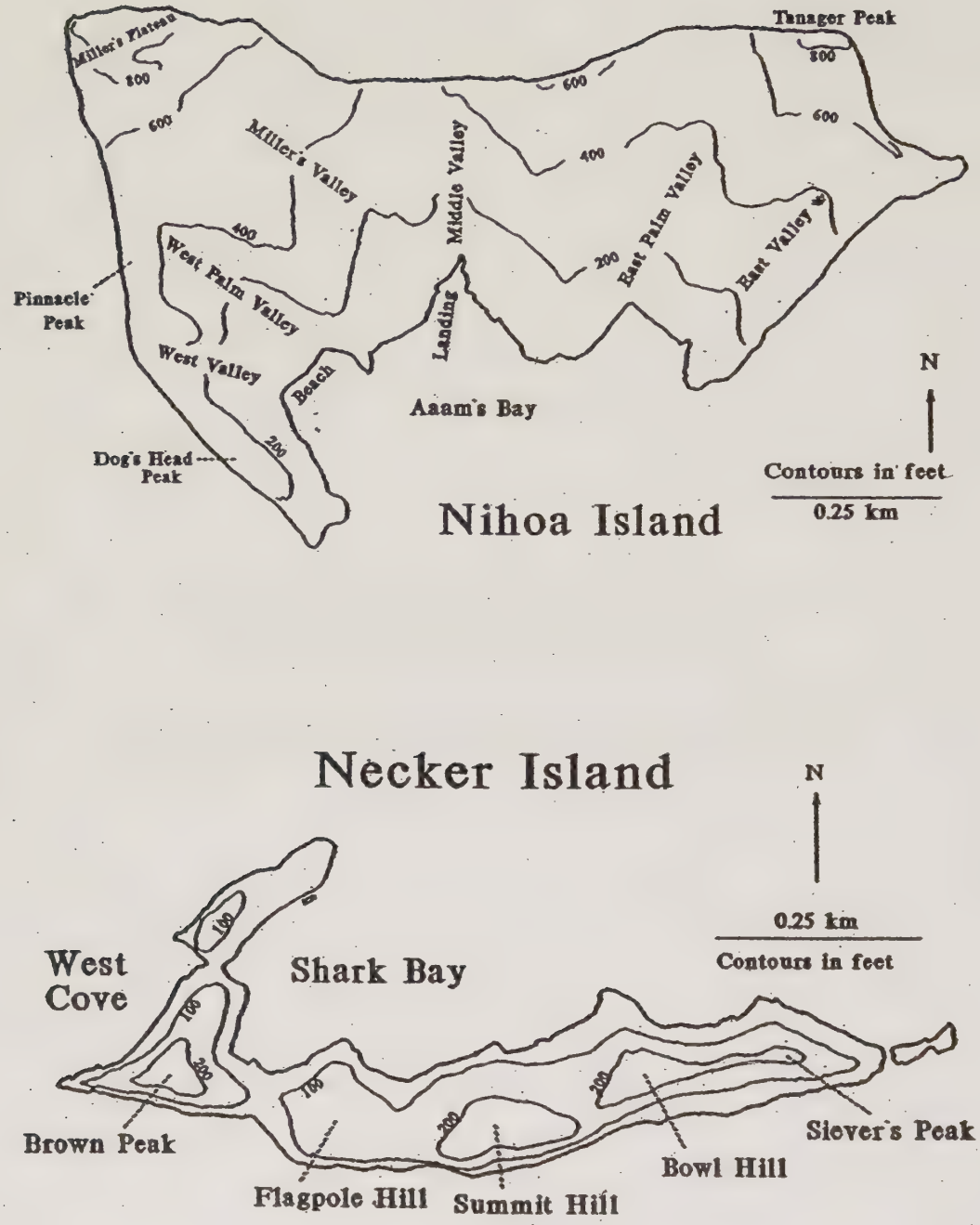

Fig. 8.1 Nihoa and Necker Islands in the Northwestern Hawaiian Islands.

Nihoa Island (lat. 23°04'N, long. 161°55'W) and Necker Island (lat. 23°36'N, long. 164°42'W) are located ca. 450 and 750 km, respectively, northwest of Oahu in the Northwestern Hawaiian Islands (Fig. 1.1). These islands lie within the Hawaiian Islands National Wildlife Refuge. Although endangered Hawaiian monk seals use these islands, their numbers are limited by lack of haulout area.

RESEARCH

In 2002, the National Marine Fisheries Service collected data at Nihoa Island on July 31 and at Necker Island on July 30. In addition, cooperating scientists collected data at Nihoa Island on September 4–8. The perimeters of Nihoa and Necker Islands were divided into 3 and 10 sectors, respectively, using natural landmarks (Fig. 8.1). In 2002, research objectives specific to the Nihoa and Necker Islands included assessment of pup production and the extent of migration between French Frigate Shoals and these locations.

Censuses and Patrols

Two entire island surveys were conducted at Nihoa in 2002: a combination beach count (of the ledge below Miller's Plateau) and boat survey (of all other haulout sites) by two observers on July 31, beginning at 0822 Hawaii Standard Time and continuing for approximately 1 h. The entire island was surveyed on foot by one observer on September 7. In addition, a partial island boat survey (of only the sandy beach) was conducted by one observer on September 8.

A partial beach count (of all haulout sites except below Bowl Hill) was conducted on Necker Island by two observers on July 30, beginning at 0825 and continuing for 4 h.

Individual Identification

On Nihoa Island, no seals were identified and no tags were noted in 2002.

On Necker Island one tagged male was observed and identified through a partial tag reading, photographs, and scar drawings as a 15-yr-old seal born at French Frigate Shoals (FFS) in 1987. Although the seal had been seen at Necker Island in 1993, he was last identified at FFS in 1994.

Collection of Samples

One scat was collected at Nihoa Island, and no samples were collected at Necker Island in 2002.

RESULTS

Subpopulation Abundance and Composition

The census totals for two counts conducted on Nihoa Island was 13 seals (10 excluding pups) on July 31 and 14 seals (12 excluding pups) on September 7. Another seal was seen in the water on July 31 but not included in the census totals. In addition, 14 seals were counted during a survey of the sandy beach on September 8. Because of limited effort, the composition of the spring-summer subpopulation was not determined.

The census total for one near complete count conducted on Necker Island was 18 seals (no pups observed) on July 30. Because of limited effort, the composition of the spring-summer subpopulation was not determined.

Reproduction

At least four pups (all of unknown sex) were born at Nihoa Island in 2002, and at least one successfully weaned. Three nursing pups were observed at Nihoa Island on July 31, and a nursing pup (new since July) and a weaned pup were observed on September 7. No pups were seen at Necker Island in 2002.

Interatoll Movement

Interatoll movement was documented for two seals. An animal last seen at Necker Island in 1999 was observed at FFS in 2002, whereas another seal last seen at FFS in 1994 was observed at Necker Island in 2002. Both seals were known-age adult males born at FFS in 1987. Interatoll movement was not documented for seals observed at Nihoa Island.

Factors Affecting Survival

Factors affecting survival were not observed on Nihoa or Necker Islands in 2002.

ACKNOWLEDGMENTS

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1990. Field manual for phocid necropsies (specifically *Monachus schauinslandi*). U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-146, 55 p.

APPENDIXES

Appendix A.--Reports summarizing annual field research on the Hawaiian monk seal by the National Marine Fisheries Service and collaborating scientists.

All islands

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Johanos, T. C., and J. D. Baker (Eds.).
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2001. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1999. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-310, 130 p.

Johanos, T. C., and J. D. Baker (Eds.).
2000. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1998. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-292, 125 p.

Johanos, T. C., and T. J. Ragen (Eds.).
1999. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1997. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-262, 131 p.

Johanos, T. C., and T. J. Ragen (Eds.).
1999. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1996. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-259, 134 p.

Johanos, T. C., and T. J. Ragen (Eds.).
1997. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1995. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-241, 121 p.

Johanos, T. C., and T. J. Ragen (Eds.).
1996. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1993. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-227, 141 p.

Johanos, T. C., and T. J. Ragen (Eds.).
1996. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1994. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-229, 111 p.

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1995. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1992. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-216, 128 p.

Appendix A.--Continued.

French Frigate Shoals

Craig, M. P., J. L. Megyesi, C. S. Hall, J. L. Glueck, L. P. Laniawe, E. A. Delaney, S. S. Keefer, M. A. McDermond, M. S. Schulz, G. L. Nakai, B. L. Becker, L. M. Hiruki, and R. J. Morrow.

1994. The Hawaiian monk seal at French Frigate Shoals, 1990-91. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-210, 70 p.

Craig, M. P., D. J. Alcorn, R. G. Forsyth, T. Gerrodette, M. A. Brown, B. K. Choy, L. Dean, L. M. Dennlinger, L. E. Gill, S. S. Keefer, M. M. Lee, J. S. Lennox, C. R. Lorence, G. L. Nakai, and K. R. Niethammer.

1992. The Hawaiian monk seal at French Frigate Shoals, 1988-89. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-178, 83 p.

Eliason, J. J., J. R. Henderson, and M. A. Webber.

1993. Hawaiian monk seal observations at French Frigate Shoals, 1985. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-187, 46 p.

Eliason, J. J., and J. R. Henderson.

1992. Hawaiian monk seal observations at French Frigate Shoals, 1984. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-177, 61 p.

Fairaizl, G. W.

1984. Intra-atoll resighting of the Hawaiian monk seal, *Monachus schauinslandi*, at French Frigate Shoals, 1 January 1983-31 August 1983. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-84-5C, 27 p.

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1984. Hawaiian monk seal observations on French Frigate Shoals, 1980. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-50, 47 p.

Laysan Island

Alcorn, D.

1984. The Hawaiian monk seal on Laysan Island: 1982. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-42, 37 p.

Alcorn, D. J., and E. K. Buelna.

1989. The Hawaiian monk seal on Laysan Island, 1983. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-124, 46 p.

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Alcorn, D. J., and R. L. Westlake.
1993. The Hawaiian monk seal on Laysan Island, 1986. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-191, 25 p.

Becker, B. L., P. A. Ching, L. M. Hiruki, and S. A. Zur.
1994. The Hawaiian monk seal on Laysan Island, 1987 and 1989. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-213, 20 p.

Becker, B. L., R. J. Morrow, and J. K. Leialoha.
1989. Censuses and interatoll movements of the Hawaiian monk seal on Laysan Island, 1985. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-135, 25 p.

Becker, B. L., K. E. O'Brien, K. B. Lombard, and L. P. Laniawe.
1995. The Hawaiian monk seal on Laysan Island, 1991. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-214, 16 p.

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1988. Hawaiian monk seal population structure, reproduction, and survival on Laysan Island, 1985. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-118, 38 p.

Johanos, T. C., B. L. Becker, M. A. Brown, B. K. Choy, L. M. Hiruki, R. E. Brainard, and R. L. Westlake
1990. The Hawaiian monk seal on Laysan Island, 1988. U.S.Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-151, 24 p.

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1984. Observations of the Hawaiian monk seal on Laysan Island from 1977 through 1980. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-49, 65 p.

Lombard, K. B., B. L. Becker, M. P. Craig, G. C. Spencer, and K. Hague-Bechard.
1994. The Hawaiian monk seal on Laysan Island, 1990. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-206, 16 p.

Appendix A.--Continued.

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Alcorn, D. J., R. G. Forsyth, and R. L. Westlake.
1988. Hawaiian monk seal research on Lisianski Island, 1984 and 1985. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-120, 22 p.

Johanos, T. C., and J. R. Henderson.
1986. Hawaiian monk seal reproduction and injuries on Lisianski Island, 1982. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-64, 7 p.

Johanos, T. C., and A. K. H. Kam.
1986. The Hawaiian monk seal on Lisianski Island: 1983. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-58, 37 p.

Johanos, T. C., and R. P. Withrow.
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Lee, M. M., L. K. Timme, R. Van Toorenburg, and B. L. Becker.
1993. The Hawaiian monk seal on Lisianski Island, 1988 and 1990. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-179, 33 p.

Stone, H. S.
1984. Hawaiian monk seal population research, Lisianski Island, 1982. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-47, 33 p.

Westlake, R. L., and P. J. Siepmann.
1988. Hawaiian monk seal and green turtle research on Lisianski Island, 1986. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-119, 18 p.

Pearl and Hermes Reef

Choy, B. K., and L. M. Hiruki.
1992. The Hawaiian monk seal and green turtle on Pearl and Hermes Reef, 1988. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-175, 18 p.

Finn, M. A., J. R. Henderson, B. L. Becker, and T. J. Ragen.
1993. The Hawaiian monk seal and green turtle at Pearl and Hermes Reef, 1990 and 1991. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-182, 29 p.

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Forsyth, R. G., D. J. Alcorn, T. Gerrodette, and W. G. Gilmartin.
1988. The Hawaiian monk seal and green turtle on Pearl and Hermes Reef, 1986. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-107, 24 p.

Kure Atoll

Bowlby, C. E., P. Scoggins, R. Watson, and M. Reddy.
1991. The Hawaiian monk seal, *Monachus schauinslandi*, at Kure Atoll, 1982-83. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-155, 28 p.

Gilmartin, W. G., R. J. Morrow, and A. M. Houtman.
1986. Hawaiian monk seal observations and captive maintenance project at Kure Atoll, 1981. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-59, 9 p.

Henderson, J. R., and M. R. Finnegan
1990. Population monitoring of the Hawaiian monk seal, *Monachus schauinslandi*, and captive maintenance project at Kure Atoll, 1988. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-150, 24 p.

Reddy, M. L.
1989. Population monitoring of the Hawaiian monk seal, *Monachus schauinslandi*, and captive maintenance project for female pups at Kure Atoll, 1987. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-123, 37 p.

Reddy, M. L., and C. A. Griffith.
1988. Hawaiian monk seal population monitoring, pup captive maintenance program, and incidental observations of the green turtle at Kure Atoll, 1985. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-101, 35 p.

Van Toorenburg, R. A., W. G. Gilmartin, and J. R. Henderson.
1993. Composition of the Hawaiian monk seal population at Kure Atoll, 1990. Pac. Sci. 47(3):211-214.

Nihoa and Necker Islands

Conant, S.
1985. Observations of Hawaiian monk seals on Necker Island, Northwestern Hawaiian Islands. 'Elepaio. 6(2):11-12.

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Finn, M. A. and M. A. Rice.
1994. Hawaiian monk seal observations at Necker Island, 1993. 'Elepaio. 55(9):55-58.

Morrow, R. J., and E. K. Buelna.
1985. The Hawaiian monk seal and green turtle on Necker Island, 1983. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-55, 11 p.

Appendix B.--Hawaiian monk seal census form and 2002 census form directions.

(See following pages.)

SEAL CENSUS FORM

ENTERED ☐

DATA TYPE _____ COMPUTER PAGE NO. ☐☐☐☐ PAGE _____ OF _____

ISLAND _____ OBSERVER ☐☐☐ TIME BEGIN ☐☐☐☐ END ☐☐☐☐

DATE _____ NUMBER _____ TEMP. ☐☐ WIND ☐☐☐ CLOUD ☐☐ Prec. ☐

Line No.	Continue	Time	Sector	Size	Sex	Beach Pos	Condition	ID			TAG				MOLT			Disturb	ASSOCIATION			Notes	Notes	EVENT	
								T/P	No.	?	No.	L/R	Col	?	%	?		Line No.	Dist	Behavior			Type	Codes
1																									
2																									
3																									
4																									
5																									
6																									
7																									
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NOTES:

CENSUSFM.GED Rev. 3/93

Line No.	Continue	Time	Sector	Size	Sex	Beach Pos	Condition	ID			TAG				MOLT		Disturb	ASSOCIATION			Notes	Notes	EVENT	
								T/P	No.	?	No.	L/R	Col	?	%	?		Line No.	Dist	Behavior			Type	Codes
15																								
16																								
17																								
18																								
19																								
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28																								
29																								
30																								

NOTES:

2002

CENSUS FORM DIRECTIONS

(Unabridged - Laysan and Lisianski Islands)

This form is used to record all Hawaiian monk seal and green turtle sightings. Turtle sightings are recorded only during census activities (not during patrols), unless noteworthy event occurs (turtle injured, tagged, tumored, mating, etc.). On the census form, all data that can be recorded for seals can also be recorded for turtles (although this data may not be required). **At French Frigate Shoals, do not record a data line for each turtle sighting; instead, write the total for each size/sex class at the bottom of the page.**

All original data should be coded in pencil. Never erase data once you have left the recording site. Instead, cross errors out with a single line so that the original information can still be read. Field editing is editing before running the data entry and checking program. All field editing by the data collector should be in blue, and field editing by others should be in red. As soon as you begin the entry and checking program, the computer will assign the computer page number and display it on the screen. At this point, be sure to fill it in on your census form. All editing after this point should be in orange. After completing the entry and checking program, check off and initial the ENTERED box on the census form.

A separate data sheet should be filled out for each date, observer, data type, and island within an atoll. If no seals are present, you should still fill out the information at the top of the census form and write "No seals" in the data area (only enter the header information and a blank line # 1). If the island itself is not present, indicate this by using 99 for the sector code, leaving the rest of the (first) line blank. To save paper, you should use a census form with multiple headers if you only have a few seals to record (i.e., at some islands within an atoll, or when recording incidental sightings before or after census or patrol). In essence, on a census form with multiple headers, each header and its associated lines represents a separate data sheet.

If two people conduct the census, they should have the same weather and the same begin and end time (i.e., both begin at the same time and place, and proceed in opposite directions until they meet on the other side of the island or islet) and combine pages into one set. Patrols may be conducted by more than one observer, but page sets are not combined, and header information may differ between page sets. Patrol observers should attempt to start at roughly the same time. The sum of all observers' patrol activity for a day should result in one complete island count.

Always record disturbance. You must be honest about this! Fill out a census form to document disturbance if you disturb a seal when you are not otherwise collecting data. On a census or atoll count, it is also assumed that condition and molt data will be taken.

Do not make up additional codes. If the need for an additional code arises, contact Honolulu.

PAGE HEADER

DATA TYPE

C =Census: A complete, timed count on an island begun around 1300. Census is conducted as quickly as possible (while gathering all information). Data collected on all seals and turtles.

A =

Atoll-wide census (must be completed within 2 consecutive days). Data collected on all seals and turtles.

B =

Behavior patrol: A complete, untimed count where size, sex, ID and disturbance are recorded. Associations are assumed to be coded for all seals. In 2002 collect at Laysan and Lisianski Islands; record spatial and pair associations, and paired male-male contests involving adult and S4 seals, otherwise code behavior X (data not taken). Record turtles only if noteworthy observation.

P =

Patrol: A complete, untimed count where size, sex, ID and disturbance are recorded. Behavior data is not taken. Record turtles only if noteworthy observation.

I =

Incidental observation. In this data type, null fields are interpreted as "data not recorded", so code data explicitly. If numbered, this indicates a full island incidental with year-specific goals. At Laysan and Lisianski Islands in 2002, these surveys will record mother-pup pairs, weaned pups, molters, survival factors (including severe harassments and mobbings) and other noteworthy observations.

T =

Tag status entry for non-active tags (tags not currently on a seal). Record tag status (F or R) in notes columns.

COMPUTER PAGE NO.

Leave this blank during data collection. It will be assigned and displayed on the screen when you enter the data. At that time, be sure to fill in the computer page number on your census form, as this number is needed for data retrieval.

PAGE Page number within a census or patrol. For example, if the census (or patrol) requires three pages, then mark the first page as "page 1 of 3" and so on. If more than 1 person conducts the census, then combine page numbers; person A has pages 1 and 2, while person B has pages 3 and 4 of a four-page census day. The maximum number of pages in a set is 9. Header information (time begin/end, date, number, and weather) should be the same for all pages within a set.

ISLAND Name of island and atoll, e.g., East, FFS.

OBSERVER

Three initials. If no middle initial, use the first and last block.

TIME BEGIN and **END**

On a 24-h clock, e.g., 6 p.m. = 1800, for the group of pages. Midway uses Midway time, all other sites use Hawaii Standard time.

DATE The date that data are collected (in YYYYMMDD format).

NUMBER Censuses, Atoll counts, Behavior patrols, and Patrols must be numbered. Each data type will have its own 3 digit number series, starting with 001. For data types other than A, have a separate number series for each islet within an atoll.

Weather information (except temperature) should be a summary of the entire day up until the end of the census or patrol, not merely an instantaneous observation. Temperatures taken in the morning are not representative for the period of data collection.

TEMP. Temperature in degrees Celsius at beginning of census or patrol.

WIND Speed:0 = no wind, calm (<5 knots)
1 = light breeze (5-15 knots)
2 = strong wind (>15 knots)
Direction:NN,NE,EE,SE,SS,SW,WW,NW
Thus, 2 N N = strong wind from north

CLOUD Cloud cover: 00 = no clouds
01-09 = 10 to 90% cover
10 = 100% cover

PREC. Precipitation: 0 = no precipitation or trace
1 = mist/drizzle
2 = rain
3 = intermittent rain

LINES

CONTINUE If the same seal sighting is recorded on several lines for any reason (e.g., additional tag or association, behavior at a later time, change of beach position), put the original line number you are continuing from here. Lines may be continued only within the same page. Fill in the original line as completely as possible. During entry, the data in all fields from TIME through MOLT must be copied from the original line if left blank on the continuation line. Do **not** copy other fields after MOLT. Several lines can have the same continuation line number.

Make a new original line (i.e. do not use continuation lines) for a seal each time that you come abreast of it on census or patrol. This is important because beach position on the original line determines if a seal is counted on census (if the seal is ashore it will be counted). When recording paired male-male contests (at Laysan and Lisianski Islands in 2002), record contests as you see them ahead of you (within 30 m). When you come abreast of the seal, record the beach position and time and make this your original line. All previously recorded lines for this sighting will be reverse continuation lines.

TIME The time should be recorded for each seal sighting, on a 24-h clock

SECTOR Location on island (e.g., 1-20 on Laysan)
Special codes as follows:
00 = unknown sector
77 = pen
88 = offshore spit/emergent reef
99 = island not present

SIZE Size is estimated using a classification scheme from Stone (1984), using the following terminology. Note that seals are "sized" by length, girth, appearance, and reproductive status, not by age (except pups):

Pup — Seals born within the calendar year. Newborn pups are black, and weight ca. 11 to 15 kg. Pups molt to a silver-gray pelage near weaning. Weaning weight is ca. 50 to 80 kg.

Juvenile — Short, slight seals from the length of a weaned pup (about 138 cm) to 20-30 cm longer; includes yearlings, and other young seals up to 3 years. Distinguished from pups by thinness and yellowish color.

Subadults — Seals perceptibly longer than juveniles up to breeding size; less robust than adults, generally with lighter pelage. Immature seals ca. 3 to 5 or 6 years old.

Adult — Reproductively active or breeding size seals at least as long as known breeders. Mature or probably mature seals. Adult females often have extensive back scars or wounds; adult males usually dark, including ventrum, and extensively scarred.

Code size as follows:

Pups of the year
- P0 = Fetus (aborted, clearly pre-term pup)
- P = Nursing pup
  - P1 = Nursing pup, wrinkles
  - P2 = Nursing pup, no wrinkles
  - P3 = Nursing pup, blimp, black
  - P4 = Nursing pup, molting
  - P5 = Nursing pup, molted
- PW = Prematurely weaned/undersized weaned pup (weaned $\leq$ 2 wks ago and < 90cm girth). Code as PW at time of weaning, and then can code as W for remainder of season.
- W = Weaned pup

Immatures
- I = Immature
  - J = Juvenile
    - J1 = Juvenile I
    - J2 = Juvenile II
  - S = Subadult
    - S3 = Subadult III
    - S4 = Subadult IV

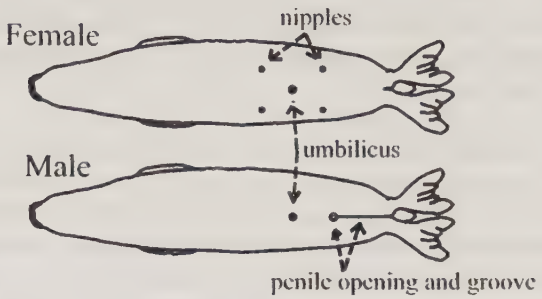
Adults
- A = Adult

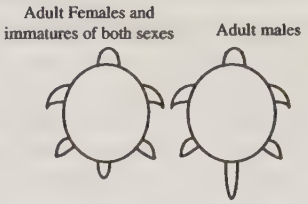
Unknowns
- U = Seal of unknown size

Turtles
- T = Turtle (lengths from anterior to posterior tip of carapace)
  - T1 = Turtle, juvenile (<65 cm straight carapace length)
  - T2 = Turtle, subadult (65 - 80 cm)
  - T3 = Turtle, adult (>80 cm)

Only code a seal's sex as known if the ventral is seen, even if you "know" the sex because of the tag, bleach, scars, or behavior. The only exception is that the mother in a mother/pup pair should be recorded as a female. The sex of a turtle can only be distinguished externally if it is adult-sized.

SEX M = Male
F = Female
U = Unknown





BEACH POS. Location of seal or turtle when observer comes abreast of animal (e.g., if seal is seen in the water from a distance and yet is on the beach when the observer come abreast, the seal is recorded as being on the beach). When recording paired male-male contests (at Laysan and Lisianski Islands in 2002), record contests as you see them ahead of you (within 30 m). When you come abreast of the seal, record the beach position and time and make this your original line. All previously recorded lines for this sighting will be reverse continuation lines.

0 = animal floating or swimming in water (not included in census tally but may be used for behavioral data or other analysis).
1 = on the beach (or regularly surveyed areas on the fringing reef for **Midway Reef Surveys)**
9 = on an offshore rock/reef with no connections to the island. Separated from shore by a deep channel or substantial distance, and not regularly surveyed (not included in census tally). For **Midway Reef Surveys**, use beach position **9** for the back side of the reef and other areas that are not regularly surveyed.
X = data not taken

CONDITION Condition is recorded for all seals (except nursing pups) on census or atoll count. **Always record** the condition of the mom on her first sighting postpartum, and of the mom and pup on their first sighting post-weaning, regardless of data type. Always note condition when recording a survival factor. Unusual conditions should be further described in **Notes**.

Condition codes:
M = medium
P = probably pregnant
F = fat
T = thin, includes emaciated
X = data not taken
Codes F and T indicate extreme conditions, seals that are medium-fat, or medium-thin should be coded as medium. **Always code condition explicitly**.

A seal is either identified or not during a sighting. If both the ID No. and Tag No. fields are empty, the seal is unidentified. If either the ID No./Tag No. field is filled, the seal may be identified depending on how the ? columns are filled. Questionable codes blank, 0, or 4 indicate the seal is identified with certainty, whereas codes 1 or 5 indicate uncertainty. If a seal's identity is confirmed by any method, coding for the entire sighting (on the original line and all continuation lines) must ultimately show certainty. For example, if the ID columns indicate the seal is identified with certainty but the Tag columns indicate uncertainty, look up the correct tag number during data editing, enter it, and change the Tag? code from uncertain (1 or 5) to certain (4)).

ID DATA These fields can be used to record either a temporary or permanent ID number. Although the paper form only has one ID field, the database actually has two ID fields. Thus, you can record both a temporary and a permanent ID number on a seal's original line (to do this on the form, split the ID field horizontally and write both numbers on a single line, or expand the original line by sacrificing the subsequent line). Use continuation lines to record two or more temporary numbers. If the seal is identified, it will not be counted twice on census. To link two sightings of an unidentified seal during a survey (i.e. for a cruiser moving ahead of you), assign it a temporary number in a series reserved for unidentified seals, and code a 6 in the temp ? field.

T/P Indicate whether the number in the subsequent field is a temporary or permanent ID number.
T = temporary ID number (or bleach number)
P = permanent ID number

TEMPORARY ID NO. Record the temporary ID number (or bleach number) of seal if known; right justified. This field may be used for any temporary number. Use separate number series for bleach and various types of temporary numbers. If a number is incompletely read, use dashes as place-holders within the number to indicate missing digits (e.g., incompletely read bleach 152 may be coded -52, 1-2, or 15-).

? column:

0 = seal is definitely unmarked; can coexist with a temporary number, or with a bleach number if bleach hasn't taken yet or the number has molted off

1 = bleach is present but the recorded bleach number is questionable, **and the seal is not identifiable** from other information

4 = partially read bleach number completed from other data

5 = incompletely read bleach number, there isn't enough information to identify the seal but the partial data are certain, **the seal is not identifiable** from other information

6 = temporary number valid for this survey only (for unident. cruisers moving ahead of you on census, etc.). Use a special number series so these numbers are not confused with real temporary ID numbers. Numbers may be reused on the next survey for different seals.

blank = number is certain and complete if present

PERMANENT ID NO. Record the 4 digit permanent ID number of seal if known (put both the island-specific prefix and next digit in the first box provided).

? column:

1 = ID number is questionable, **and the seal is not identifiable** from other information

blank= ID number is certain and complete if present. A Permanent ID is not visible, and is always completed from other data. For certain ID numbers, **always use ID? = blank, not ID? =4.**

TAG NO. The complete tag number if known; right justified. If a number is incompletely read, use dashes as place-holders within the number to indicate missing digits. Put the alpha prefix of the temple tag (combined with tag ? column code = 5) if you can determine the hole drilling pattern, but can't decipher the number (e.g. A--RT5 for a right tan tag with a 1983 drill pattern). Explain how you came up with the prefix, and draw the hole drill pattern in Notes.

Record all tag sightings explicitly (i.e., both left and right tag numbers) at least once during your stay. During the first weeks of the field camp, note tag condition each time that a tag is sighted. Once the majority of tags have been resighted, observers can carry a list of tags/individuals that haven't been seen, and only note tag condition if these tags/individuals are resighted. Also carry a list of broken or lost tags, and current tag conditions, so that you will be aware, and can record, if a specific tag breaks or is lost, or a tag condition changes during the field season. When a pup is tagged, record the animal handling event on the census data sheet, and record detailed information (such as all tag numbers, all temporary numbers, and the permanent number) on a Tagging/Handling card. If a seal is identified via a tag, it is not necessary to determine and enter its ID number on the census form. The ID number can be determined by computer later.

L/R: Tag position

L = tag on left flipper
R = tag on right flipper
B = tags on both flippers (enter one tag number). This code can be used if the seal has only 2 Temple tags (one on each flipper).

COL: Color code -see the Tag Sample Kit if unsure of the colors

Temple tags	Other tag types
Y = yellow (FFS)	M = metal, Monel
T = tan/brown (Laysan)	C = clear, PIT tag
G = green (Lisianski)	
B = blue (Pearl & Hermes)	
K = silver/gray (Kure)	
R = red (Midway, Necker, Nihoa, Main Islands)	

? column:

0 = seal is definitely not tagged on **either** flipper. To indicate that a seal has lost a tag, code a known missing tag using tag? code 8. If the tag number is unknowable, write the information in Notes.
1 = seal is tagged but the recorded tag data are questionable, and **the seal is not identifiable** from other information
4 = partially read tag completed from other data
5 = incompletely read tag, there isn't enough information to identify the seal but the partial data are certain, **the seal is not identifiable** from other information
8 = a specific tag is lost/unreadable. Fill out tag position (L/R) and the tag condition event with codes L or U. Complete the tag number and color from other data before entry.
blank = tag information is certain if present. Partial data (either complete Tag #, position, or color not filled) are OK and will be completed by computer if the seal is identified by ID, Temporary #, or Tag #. The computer will only fill blank fields, so an incomplete Tag # must be completed by hand (use a "4" in the tag ? column).

MOLT Percentage of old pelage lost, optional for pups. However, for weaned pups, record the % molt at time of tagging. Record molt as 100% for at least 1 month post-molt.

blank	=	no molting evident
0-9	=	1 to 99% molted. 0 = molting, but less than 10%; 1 = 10-19%; 2 = 20-29%; ... 9 = 90-99%. The first signs of molt usually occur around the eyes, nose, flippers, and scars. **The first record of a ≥ 2 molt is considered the first day of true molt.**
10	=	100% molted, freshly molted, **required for the first month after molt**. Put both digits of the 10 in the single box provided.

? column:

0 = seal is definitely not molting

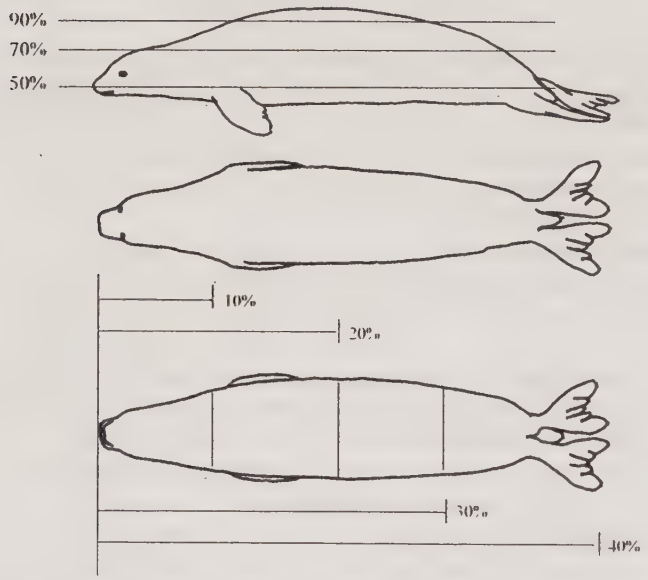
1 = seal is molting, but % molt estimate is questionable. May or may not include an estimate in the molt column

"End of season" editing codes that override erroneous molt estimates:

2 = seal in molt

3 = seal pre-molt

4 = seal post-molt



DISTURB The degree to which the seal may have been disturbed by observer. Record disturbance every time a seal is disturbed, regardless of your activity. The only exception is that you do not need to record a disturbance for a seal that you are handling (i.e., tagging, disentangling).

0 = no disturbance, or seal merely raised its head or looked at observer - If column **blank**, 0 is assumed

1 = seal vocalized, gestured, or moved ≤2 body lengths

2 = seal alerted to observer and moved >2 body lengths

3 = seal alerted to observer and fled into water

ASSOCIATION DATA

Behavior data is collected at Laysan and Lisianski Islands because adult male aggression has been more commonly observed at these locations, resulting in injury and death of adult female and immature seals. At Laysan, these data were used to identify 37 males for removal in a successful management action that reduced the adult sex ratio and increased female survival. Data are now used to monitor the long term effects of sex ratio adjustment at Laysan, and assess management options at Lisianski Island.

Record spatial and pair associations involving adult and S4 seals at Laysan and Lisianski Islands in 2002. Don't record associations that only involve S3 or smaller sized seals or associations that involve turtles. If you wish to indicate that a seal was alone, use the O (this code is alpha, not zero!) behavior code. If you do not record association data on a census or behavior patrol at Laysan or Lisianski Island for any reason, indicate this with an X for the behavior code. **Always explicitly record whether the seal is unassociated or association data is not recorded.** Use continuation lines to record more than one association.

An association should either be all blank or have the O or X behavior only (with no line number or distance), or have a line number, a distance, and some behavior code (other than O or X) all present.

All associations should be recorded in pairs, i.e., between animals on two different lines. You should fill in the line numbers, distances, and behavior codes for both animals involved in the each association. The association line number should refer directly to the line where the corresponding behavior is coded (i.e. if the corresponding code is on a continuation line, refer to that particular line, not to the original line or a different continuation line). If two seals are associated, the time recorded on their lines doesn't need to match, but should be within 30 minutes of each other.

Active associations will not be recorded in 2002. However, if a **paired male-male** contest occurs write a brief summary in **Notes** and code the contest outcome (see the attached **CONTEST RULES**).

Spatial associations

1) noted as observer comes abreast of the subject
2) individual seals
   - mother-pup pair (N): any distance
   - Adult or S4 seals (L): distances ≤10 m away, record two nearest neighbors, can be on opposite sides of a log, etc.

LINE NO. Identity of the other seal in the association. Put its line number here (note line number refers to within same census page only).

DIST. Closest distance during behavior - both associated lines must have the same minimum distance.

0 = body contact
1 = <2 m
2 = 2-5 m
3 = >5 m (>5 m but ≤10 m in the case of L behavior code)

BEHAVIOR Up to four behaviors may be recorded for each association, but L, N, X, and O should not appear together with other behaviors. If there is a **paired male-male** contest write a brief summary in **Notes**. **Focus on the major points**, such as the seals involved, pairings before and after the interaction, the contest winner/loser, and the most intense behaviors (joust, bite, mount, chase, displace).

1) individual seal

a) spatial association

N =mother-pup pair (any distance), does not imply actual nursing behavior. This is the only association recorded between mother-pup pairs unless there is an unusual event (i.e., pup switch). If other behaviors are recorded, the N association must be on the original line for each pair member.

L =association by location only (distance ≤10 m apart, for all except mother-pup pairs)

b) additional codes (Laysan and Lisianski 2002)

*L1 = pair assoc. A/S4 male actively defends an adult female or immature of either sex (actual sex may be unknown), or establishes a pair relationship with a female or immature after displacing another male. Code the L1 relationship both before and after the contest if a displacement occurs.

*Q = loser (quitter)

*W = winner

*Y = tie

Note: codes Q, W, and Y are used for A/S4 male-male contests only, although the actual sexes may be unknown (in which case record as though they were known to be males); see the attached **CONTEST RULES**.

* requires a corresponding code on the line of the associated seal

Code	Corresponding code
N	N
L	L
L1	L1
Q	W
W	Q
Y	Y

2) nothing nearby

O = no behavior or association

3) no data

X = no association data recorded on Census or Atoll Count

NOTES--There is room to code 2 different notes. Always use the first column first. Code an H if you have handwritten notes on the observation. Put handwritten notes on the bottom of the census form, labeled by line number. If more than two note codes apply, use continuation lines.

A = artwork (scars drawn) - attach drawing, labeled with date, island, observer, data type, page number, and line number

B = birth, 1st sighting postpartum (mom and pup)

G = seal is green with algae

H = handwritten notes

M = marked, indicate each time a seal is bleached (includes attempts to bleach)

W = weaning, 1st sighting post-weaning (pup or mom, whichever sighting confirms weaning or end of nursing (i.e., mom alone after pup disappearance).
X = pup exchange, 1st sighting after exchange (mom and pup)
Y = disturbance is to "bystander" seal during non-survey activity such as tagging, bleaching, instrumenting, etc. This includes all "hands on" research, even if the attempt was unsuccessful.

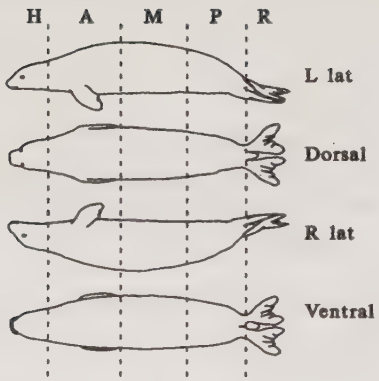
FOR DATA TYPE "T", STATUS OF NON-ACTIVE TAGS (TAGS NOT CURRENTLY ON SEALS):
F = found
R = recovered from seal in hand

EVENT These columns are used to record a variety of data. The codes used will depend upon the type of event that you wish to record. Left justify your coding:

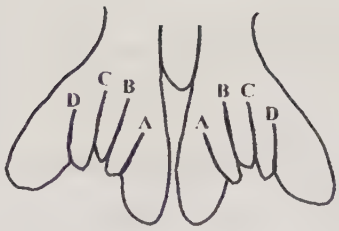
TYPE	**CODES COLUMN**	**CONTENT**
F = survival factor		ONLY RECORD RESIGHT OF A SURVIVAL FACTOR AS AN EVENT IF THERE ARE IMPORTANT CHANGES TO DOCUMENT, SUCH AS A NEW WOUND, HEALING, DEATH, ETC., TRANSCRIBE NOTES TO SURVIVAL FACTOR FORM. FOR TURTLES, USE A DIFFERENT SURVIVAL FACTOR NUMBER SERIES (I.E., BEGIN AT 500), FILL OUT A SURVIVAL FACTOR FORM (OR USE AN ALTERNATE FORMAT IF SPECIFIED BY MTRP), BUT DO NOT ENTER THE DATA INTO THE SEAL SURVIVAL FACTOR DATABASE.
	1-3	Survival Factor number
	4	Factor Type. If seal dead, always record factor type "D" on ORIGINAL LINE. For mobbings/ harassments, always code a census entry with factor type "M" for the victim at the beginning and end of the incident. Otherwise, you only need to record the most appropriate factor type if more than one applies. D = death W = wound E = entanglement V = very thin (emaciated) I = illness/abnormal (includes eye disease) M = mobbing/harassment/post-mobbing aggregation O = other
	5	Participant type (for mobbings/ harassments/post-mobbing aggreg. only) V = victim/subject M = male aggressor
H = handling of wild seal		FOR SEAL CAPTURES OR RELEASES, RECORD DETAILS ON EITHER THE CAPTURE OR RELEASE FORM. OTHERWISE, RECORD DETAILS ON THE TAGGING/HANDLING CARD. HANDLING DOES NOT NECESSARILY INVOLVE RESTRAINT OF SEAL.
	1	Handling type T = tagging (w/ restraint) M = measuring (includes weighing)

A = all (both tagging and measuring)
R = remote tagging
D = disentangle (even if not restrained)
I = instrument application
B = bleeding
C = take into captivity
F = free from captivity
O = other (includes instrument removal and the translocation of seals within an atoll)

TYPE	CODES COLUMN	CONTENT
P = photo		SEAL OR TURTLE PHOTOS ARE THE ONLY PHOTOS CODED ON THE CENSUS FORM. OTHER PHOTOS SHOULD BE RECORDED IN NOTES, AND TRANSFERRED TO THE PHOTO COMMENT FORM.
	1	Type of photo S = slide P = print D = digital
	2-3	Roll number (pad with zeros)
	4-5	Frame number (pad with zeros)
	6	Side L = left lateral or flipper R = right lateral or flipper D = dorsal side V = ventral side B = both (used for rear flippers only) X = other, describe in hand-written NOTES
	7	Part H = head A = anterior body (neck and shoulders) M = midbody (behind fore-flippers and before posterior) P = posterior body (behind midbody and before rear flippers) F = foreflipper; write whether dorsal/ventral in comments R = rearflipper; write whether dorsal/ventral in comments O = overall view of a particular side X = other, describe in comments
	8	Purpose I = identification F = survival factor (link with survival factor EVENT using continuation lines) X = other, describe in comments



TYPE	CODES COLUMN	CONTENT
T = tag condition		RECORD TAG CONDITION FOR BOTH SIDES OF EACH TAG AT LEAST ONCE DURING THE SEASON. IF TAG CONDITION IS RECORDED FOR AN INCOMPLETELY READ TAG, COMPLETE THE TAG NUMBER (WITH APPROPRIATE TAG? CODE) PRIOR TO COMPUTER ENTRY.
	1	Web



A-D = from inner (medial) to outer web.
E = ankle
P = posterior
U = unknown

2 Side of tag, the dorsal tag side is on the dorsal flipper surface unless the tag is reversed. For Temple Tags, the dorsal side is the bigger side; for Metal (Monel) tags, the dorsal side is the "male" side. For PIT tags, code the side as B (both).

D = dorsal
V = ventral
B = both
U = unknown

3 Condition, code U (unreadable) if cannot use tag to ID seal (i.e. if broken so number gone). Also code U for a PIT tag if you completely scan for it with a reliable reader but get no reading. If reader is unreliable, put attempt in Notes and only code PIT tag as unreadable after 3 separate attempts. Combine the L or U codes with the tag questionable code of 8. You can combine the tag questionable code of 8 with other condition codes to describe why the tag is unreadable (i.e., worn or broken). Unreadable tags can still be used as partial information to help determine a seal's identity. Code more than one condition using continuation lines.

B = broken
F = faded color
G = good
L = tag lost
N = no/partial resin
O = other
P = pulling out
U = unreadable
V = tag side reversed
W = no. worn /abraded

CONTEST RULES

1. **Male-male contest definition** (must conform to at least one condition below):
   a. Distance between adult males = 0
   b. Either adult male vocalizes, chases, displaces or jousts with the other male

2. **The contest outcome depends upon pair type** (what size/sex seal the adult male is paired with)
   a. For contest rules, size S4 seals are considered to be adults (both sexes), seals size S3 or smaller are considered to be immature
   b. Definition of (L1) pair type:
      i. Pair type **#1**: adult male paired with (actively defending) an adult female
      ii. Pair type **#2**: adult male paired with (actively defending) an immature seal of either sex

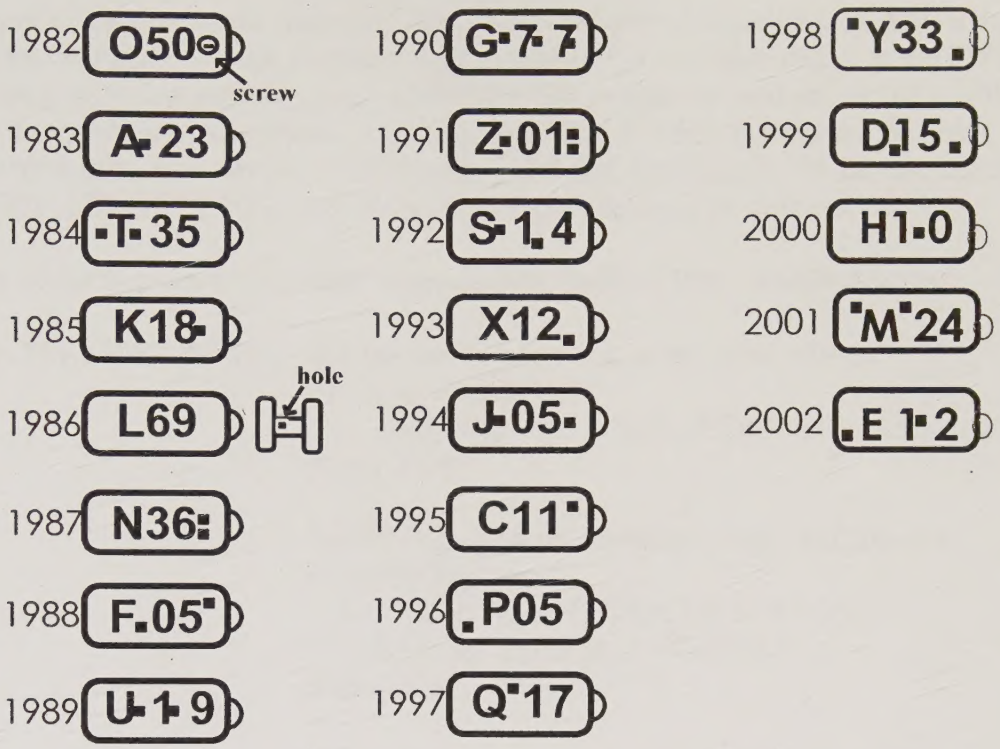
3. **Contest outcomes** (definition of winner or loser adult male):

Case		Winner (W)	Loser (Q)	Tie (Y)
Paired Male *vs.* Single Male:	i)	The paired male wins if he is not displaced	Unsuccessful single male	No Ties
	ii)	The single male wins if he displaces the original paired male	Displaced originally paired male	No Ties
Male Paired with Adult Female *vs.* Male Paired with Immature Seal: (**#1** *vs.* **#2**)	i)	The male paired with the adult female wins if he is not displaced	Unsuccessful male paired with immature	No Ties
	ii)	The male paired with the immature seal if he displaces the male originally paired with the adult female	Displaced originally paired male	No Ties
Paired Male *vs.* Paired Male of equal pair type: (**#1** *vs.* **#1** or **#2** *vs.* **#2**)		Displaces the other seal	Is displaced	Tie if neither seal is displaced

4. **Generalizations:**
   a. **Unequal pair types**
      i. There are no ties
      ii. The male with the **higher pair type (1>2) always wins unless he is displaced**
      iii. A seal can win without being aware of the contest. For example, if the "winner" is not aware that the other seal flees, but that seal fled in response to a vocalization, then code the fleeing seal as the loser (Q) and the other seal as the winner (W))

   b. **Equal pair types**
      i. **Males tie unless there is a clear winner/loser**
      ii. To win, a male must displace the other male

HAWAIIAN MONK SEAL TEMPLE TAGS:
NUMBERING SCHEME AND HOLE DRILLING PATTERN FOR TAGS APPLIED TO WEANED PUPS



Be sure to code the original tag color, not the color that a tag has faded to. See the Tag Sample Kit.

Original tag color:	**Faded tag may appear:**
Temple Tags:	
Yellow	White, Lt. Yellow
Light Tan (A,T,K,L series @ Laysan)	Gray, Lt. Yellow, White
Dark Tan/Brown (later series @ Laysan)	Red
Dark Forest Green	Dark Blue, Navy
Kelly Green (C, P, and Y cohorts)	--
Blue (light)	--
Red	Orange
Gray (A,T,K,L,N,F,U,G series @ Kure)	Light Tan
Silver Gray (600-900,0,Z and later @ Kure)	Metal

Availability of NOAA Technical Memorandum NMFS

Copies of this and other documents in the NOAA Technical Memorandum NMFS series issued by the Pacific Islands Fisheries Science Center are available online at the PIFSC Web site http://www.pifsc.noaa.gov in PDF format. In addition, this series and a wide range of other NOAA documents are available in various formats from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161, U.S.A. [Tel: (703)-605-6000]; URL: http://www.ntis.gov. A fee may be charged.

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NOAA-TM-NMFS-PIFSC-1 The Hawaiian monk seal in the Northwestern Hawaiian Islands, 2001.
T. C. JOHANOS and J. D. BAKER (comps. and eds.)
(April 2004)

2 Contingency plan for Hawaiian monk seal Unusual Mortality Events.
P. K. YOCHEM, R. C. BRAUN, B. RYON, J. D. BAKER, and G. A. ANTONELIS
(May 2004)

3 Modeling a very rare event to estimate sea turtle bycatch: lessons learned.
M. L. MCCRACKEN
(November 2004)

4 Evaluation of time-area closures to reduce incidental sea turtle take in the Hawaii-based longline fishery: generalized additive model (GAM) development and restrospective examination.
D. R. KOBAYASHI and J. J. POLOVINA
(March 2005)